Physical Activity and Sedentary Behavior Among US Children with and Without Down Syndrome: The National Survey of Children's Health

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ABSTRACT

It is unclear whether children with Down syndrome have differing physical activity and sedentary behavior levels compared to typical children. This study addressed this evidence gap in a national sample. Physical activity/sedentary behavior were ascertained by parental report. Findings highlighted that children with Down syndrome were less likely to engage in regular physical activity compared to typical children and had the lowest likelihood of regular physical activity among all subgroups with developmental disabilities/special healthcare needs. Children with Down syndrome were also more likely to watch high volumes of television compared to typical children, although this was non-significant upon adjustment for general health. It was concluded that children with Down syndrome are in urgent need for interventions/programs that promote physical activity.

Key words: Down syndrome, physical activity, sedentary behavior, epidemiology, pediatric

INTRODUCTION

Down syndrome is the most common chromosomal disorder in the United States, occurring in ~1 in 700 births and prevalent in ~250,000 individuals (Parker et al., 2010; Presson et al., 2013). Down syndrome is characterized by intellectual disability and risk for co-morbidities including congenital heart disease, sleep apnea, gastrointestinal anomalies, and visual and hearing impairments (Roizen & Patterson, 2003). It is furthermore characterized by gross motor deficits and delays in development during childhood that are attributed to muscle hypotonia, joint hypermobility, ligamentous laxity, and abnormal alignment and movement at the foot, ankle, knee, and hip (Mik, Gholve, Scher, Widmann, & Green, 2008; Roizen & Patterson, 2003). As such, children with Down syndrome may have a diminished ability to engage in physical activity and subsequently may be predisposed towards greater cardiometabolic risk both in adolescence and into adulthood (Fox, Moffett, Kinnison, Brooks, & Case, 2019). For example, children and adults with Down syndrome have higher rates of obesity relative to their peers (Bertapelli, Pitetti, Agiovlasitis, & Guerra-Junior, 2016; Melville, Cooper, McGrother, Thorp, & Collacott, 2005).

Regular physical activity is an essential health behavior for promoting overall health and well-being across the lifespan (Warburton, Nicol, & Bredin, 2006). In children and adolescents, higher amounts of physical activity are favorably linked to indicators of cardiometabolic and bone health (Janssen & Leblanc, 2010). Evidence suggests these health benefits carry forward into adulthood (Fernandes & Zanesco, 2010; Mantovani et al., 2018; Palve et al., 2014). Accordingly, physical activity guidelines recommend children and adolescents engage in ≥60 minutes of moderate-to-vigorous aerobic physical activity (MVPA) daily, as well as bone-strengthening, and muscle-strengthening physical activities for ≥60 minutes on at least 3 days a week (Piercy et al., 2018). With recognition that sedentary behavior (e.g. TV viewing, video gaming, computer use, etc.) may constitute a clinically important aspect of a person's physical activity profile that confers health risk irrespective of MVPA (Biswas et al., 2015), some guidelines also recommend children minimize time spent sedentary (Garber et al., 2011; Tremblay, Carson, & Chaput, 2016). These recommendations apply to most children, including those with Down syndrome.

Individuals with Down syndrome have seldom been included in epidemiological studies on physical activity. Thus, to date, few population-based studies have examined physical activity levels and sedentary time among children with Down syndrome and whether their physical activity levels and sedentary time differ relative to their peers. While some studies have examined differences in physical activity and sedentary behavior in children with Down syndrome compared to typically developing children, these studies have been limited to small sample sizes of participants (n <30) from a single geographic region and typically recruit from samples of convenience (Fox et al., 2019; Frey, Stanish, & Temple, 2008). The small sample sizes in prior studies have precluded robust covariate adjustment (with adjustment for only age in some). Prior studies furthermore have not accounted for important contributing factors (obesity, access to youth sports, health status) or examined whether the differences in physical activity/sedentary behavior between children with Down syndrome and typically developing children are any more pronounced than the difference between typically developing children and children with other special health care needs. The purpose of this study therefore was to examine differences in physical activity and sedentary behavior among a population-based sample of children with Down syndrome, children with other special health care needs, and typically developing children.

METHODS

Study Population: Data for this analysis come from the 2016 and 2017 National Survey of Children's Health (NSCH), a nationally representative, parent-completed survey of US children aged 0 to 17 years that was funded and directed by the Health Resources and Services Administration's Maternal and Child Health Bureau (MCHB) and conducted by the US Census Bureau. Sample design, data collection procedures, and questionnaire content are available online (www.childhealthdata.org/learn-about-the-nsch/NSCH). Briefly, randomly selected households from all 50 states are mailed a screener questionnaire querying information pertaining to the children in the household, with the opportunity to complete online or via mail. Households with children were identified, and one child from each household was randomly

chosen, with oversampling for children with special health care needs using the MCHB's Children With Special Health Care Needs Screener (Bethell et al., 2002). A comprehensive topical questionnaire about this child (and the caregiver) was then completed online or via mail by a parent. A detailed summary of measures collected from this questionnaire that were included as covariates in the present analysis are provided in the Online Supplement.

Across the 2016 and 2017 surveys, 71,811 out of 199,058 (36.1%) eligible households completed the topical questionnaire. Children under than age of 6 were not administered questionnaires ascertaining physical activity, thus the present analysis is restricted to children aged 6-17 years (n=51,156). After further excluding children aged 6-17 years with missing data for physical activity measures (n=965), a total of 50,191participants were included in the final analytic sample. The NSCH study adhered to the US Federal Policy for the Protection of Human Subjects. The NSCH does not undergo an external review by institutional review board. Instead, the process for the review of methods and procedures is incorporated into the responsibilities of the US Census Bureau and Office of Management and Budget officials. All participants provided informed consent.

Classification of Typically Developing Children, Children with Other Special Health Care Needs, and Children with Down syndrome: Children with special health care needs were identified using the Children With Special Health Care Needs Screener, a widely used tool for identifying children with greater than typical need for healthcare due to chronic illness or disability that was designed to operationalize the MCHB's definition of children with special healthcare needs (Bethell et al., 2002). Children are classified as having special health care needs if they meet at least one of five criteria pertaining to any medical, behavioral, or other health condition lasting or expected to last ≥ 1 year: (1) needing or using a prescription medication; (2) needing or using more health or educational services than is usual for children of the same age; (3) being limited in their ability to do things most children of the same age can do; (4) needing or receiving special therapy (e.g., physical therapy); or (5) needing or receiving treatment or counseling for a chronic emotional, developmental, or behavioral problem. In

addition, the NSCH topical questionnaire also ascertained the presence of specific developmental conditions. For each condition other than hearing and vision impairment, parents were asked, “Has a doctor or other health care provider ever told you that this child has [CONDITION]?”. The conditions that were queried included “Down syndrome”, “autism or autism spectrum disorder (ASD)”, “cerebral palsy”, “intellectual disability (formerly known as mental retardation)”, and “developmental delay”. Vision and hearing impairments were determined by parent answer to the questions “Does the child have any blindness or problems seeing even when wearing glasses?” and “Does the child have any deafness or hearing problems?”

Children were categorized into one of 5 possible groups: typically developing, Down syndrome, or 3 mutually exclusive other special health care needs comparison groups. The 3 other special health care needs comparison groups were classified using the following hierarchy: (1) children with a developmental disability that had a high functional impact: autism, cerebral palsy, vision impairment, or hearing impairment; (2) children with a developmental disability, but who did not have Down syndrome or any of the aforementioned high impact developmental disabilities; and (3) children with other special health care needs (e.g. meeting at least one of the five criteria from the Children With Special Health Care Needs Screener; but not classified in any of the groups above). Any child not classified as having Down syndrome or other special health care needs (as defined in the three groups above) was classified as a typically developing child.

The selection of three other special health care needs comparison groups is consistent with previous studies which demonstrated that Down syndrome, autism, cerebral palsy, visual impairment, and hearing impairment were associated with the greatest health and functional impacts(Boulet, Boyle, & Schieve, 2009; Schieve, Boulet, Kogan, Van Naarden-Braun, & Boyle, 2011) and allowed for comparisons of whether the differences in physical activity/sedentary behavior of children with Down syndrome relative to typically developing children are any more pronounced than in children that have other special healthcare needs with similar or lesser functional impact.

Physical Activity and Sedentary Behavior Measures: Physical activity was assessed by parental response to the question, "During the past week, on how many days did this child exercise, play a sport, or participate in physical activity for at least 60 minutes?" with response options of 0 days, 1-3 days, 4-6 days, or every day. Parental report of children's physical activity has been validated against accelerometry (r=0.41-0.60) and heart rate (0.72-0.82) (Sallis, 1991; Sirard & Pate, 2001). Consistent with evidence in youth which suggest that 4 days/week of exercise is sufficient to yield improvements in cardiorespiratory fitness (Baquet, van Praagh, & Berthoin, 2003), a strong marker of current health among children/adolescents that is predictive of cardiovascular health later in life (Ortega, Ruiz, Castillo, & Sjostrom, 2008; Ruiz et al., 2009), children were classified as engaging in "regular physical activity" if ≥4 days was reported.

Sports participation was assessed by parental response to the question "During the past 12 months, did this child participate in a sports team or did he or she take sports lessons after school or on the weekends?" with response options of yes or no.

Sedentary behavior was assessed with two items that assessed TV viewing and electronic device use, two of the most common sedentary behaviors among children and adolescents (Atkin, Gorely, Biddle, Marshall, & Cameron, 2008; Harrell et al., 2003; Utter, Neumark-Sztainer, Jeffery, & Story, 2003). Time spent in the two sedentary behaviors was assessed by the questions "On an average weekday, about how much time does this child usually spend in front of a TV watching TV programs, videos, or playing video games?" and "On an average weekday, about how much time does this child usually spend with computers, cell phones, handheld video games, and other electronic devices doing things other than schoolwork?" Response options for both of these questions were none, less than 1 hour, 1 hour, 2 hours, 3 hours, or 4 or more hours. Consistent with guidelines for screen time (Strasburger et al., 2013; Tremblay et al., 2016), TV viewing and electronic device use were each dichotomized as ≤2 h/day and >2 h/day.

Statistical Analyses: Characteristics of the sample (e.g. means, frequencies) were calculated stratified by child classification: typically developing children, children with Down syndrome, and children with other special healthcare needs (calculated separately for all 3 groups: with high-impact developmental disability, without high-impact developmental disability, or other). Cohen's effect size *d* values (for continuous variables) and *h* values (for categorical variables) were calculated and used to interpret differences in covariates across child groups; with effect sizes ≥0.20 set as a threshold for meaningful differences between groups (Cohen, 2013).

Logistic regression modeling was used to calculate the odds ratio (OR) for physical activity (regular physical activity, sports participation) and sedentary behavior (TV viewing ≥2 h/d, electronic device use ≥2 h/d) associated with Down syndrome and other special healthcare needs (all 3 groups) versus typically developing children. Crude ORs were initially calculated. Subsequently, ORs were calculated adjusted for age, sex, race, Hispanic ethnicity, household educational achievement, born outside United States, and household poverty level (Model 1), with further adjustment for general health (Model 2). The above analyses were then repeated in a fully adjusted model testing interactions for age (6-11 and 12-17 years) and sex (male and female).

As sports participation may account for differences in physical activity between children with special healthcare needs/Down syndrome and typically developing children, models with regular physical activity as the outcome variable were additionally adjusted for sports participation in a secondary analysis. We did not adjust for body mass index (BMI) in our primary models because BMI classification in the NSCH was limited to only children aged 10-17 years. As an exploratory analysis, the above analyses were repeated additionally adjusting for BMI classification in the restricted sample (e.g. aged 10-17 years). All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC). Due to the small number of children with Down syndrome in the analytic sample (n=102), the NSCH sampling weights were not used because of the likelihood of large standard errors and imprecise estimates.

RESULTS

Participant Characteristics: Demographic characteristics of children with Down syndrome, children with other developmental disabilities or special health care needs, and typically developing children are shown in Table 1. Children with Down syndrome were more likely to live in households with lower incomes and were less likely to have excellent general health compared to typical children. The prevalence of regular physical activity, sports participation, TV viewing ≥2 h/day, and electronic device use ≥2 h/day among children with Down syndrome, children with other developmental disabilities or special health care needs, and typically developing children is shown in Figure 1. The prevalence of regular physical activity was 56.3%, 48.5%, 45.1%, 38.3%, and 32.4% for typically developing children, children with other special health care needs, children without high impact developmental disabilities, children with high impact developmental disabilities, and children with Down syndrome, respectively.

Association of Down syndrome with Physical Activity and Sedentary Behaviors: In unadjusted and partially adjusted models, children with Down syndrome had a significantly lower odds of engaging in regular physical activity compared to typically developing children (Table 2). Children with developmental disabilities (with or without high functional impact) or other special health care needs also had a significantly lower odds of engaging in regular physical activity in unadjusted and adjusted models compared to typical children, although children with Down syndrome had the lowest likelihood of not engaging in regular physical activity (45% less likelihood relative to typical children vs. 8-37% less likelihood for other groups in most adjusted model). Adjustment for general health attenuated the associations, however all group differences remained statistically significant. Adjustment for sport participation also attenuated the associations, however children with Down syndrome (OR: 0.63 [95% CI: 0.41, 0.98]), children with high impact developmental disabilities (OR: 0.80 [95% CI: 0.73, 0.88]) and children with other special health care needs (OR: 0.94 [95% CI: 0.90, 0.99]) still were significantly less likely to engage in regular physical activity relative to typical children. Similarly, in unadjusted and adjusted models, children with Down syndrome and children with other developmental disabilities or other special health care needs were significantly less likely to participate in sports relative to typical

children. All results were similar with additional adjustment for BMI classification in a sample restricted to ages 10-17 years (Supplemental Table 1) and did not vary by age or sex (interaction p-values >0.10).

When examining sedentary behaviors, in unadjusted and partially adjusted models (Model 1, Table 2), children with Down syndrome were significantly more likely to watch TV >2 h/day compared to typical children. However, this association was no longer statistically significant after adjustment for general health. There was no significant association comparing children with Down syndrome to typical children for electronic device use >2 hours/day. Compared to typical children, children with high impact developmental disabilities and children with other special health care needs were significantly more likely to watch TV or use electronic devices for >2 hours/day in unadjusted and adjusted models. Results did not vary by age or sex (interaction p-values >0.10).

DISCUSSION

In this large national survey of children in the US, children with Down syndrome were 45% less likely to engage in regular physical activity and 52% less likely to participate in sports relative to their typically developing peers. Notably, children with Down syndrome exhibited more pronounced reductions in their likelihood of participating in regular physical activity versus typically developing children than children with other developmental disabilities or special health care needs. It was furthermore observed that children with Down syndrome were more likely to watch high volumes of TV (>2 hours/day) compared to typically developing children, albeit this finding was not statistically significant after accounting for general health. These findings highlight children with Down syndrome as a high risk target population with an urgent need for tailored interventions and community programs that promote physical activity to reduce health disparities.

A recent systematic review identified 3 studies that evaluated differences in physical activity levels among children with Down syndrome compared to typically developing children (Fox et al., 2019); 2 of which reported that children with Down syndrome have lower physical activity levels(Matute-

Llorente, Gonzalez-Aguero, Gomez-Cabello, Vicente-Rodriguez, & Casajus, 2013a, 2013b). Accelerometry, the preferred method for assessing physical activity in children, was importantly utilized in these prior studies and provided strong initial evidence that children with Down syndrome have lower levels of physical activity relative to their peers. However, these prior studies were limited in that they had small sample sizes (n <30) and were unable to account for key covariates other than age. When sociodemographic and health characteristics including age, sex, race, income, maternal education, and BMI were accounted for in a study by Whitt-Glover et al., differences in physical activity between children with Down syndrome and their typically developing siblings, which were significant in unadjusted models, were no longer statistically significant (Whitt-Glover, O'Neill, & Stettler, 2006). As such, Pitetti et al. have contended that the existing data do not allow for investigators to conclude with definitive confidence whether children with Down syndrome have lower levels of physical activity than typically developing children (Pitetti, Baynard, & Agiovlasitis, 2013). The present study, thus addresses important evidence gaps and confirms and extends upon previous work to show in a population-based sample that children with Down syndrome are less likely to engage in regular physical activity than typically developing children. Importantly, these findings are independent of differences in physical health, sports participation, and overweightness/obesity, as well as key demographic (sex) and socioeconomic (parental education, household income) indicators; potentially contributing factors that were largely unaccounted for in prior studies. Furthermore, the present study is the first to show that the lower rates of regular physical activity in children with Down syndrome are more pronounced than in children with other developmental disabilities or special health care needs. Children with Down syndrome had a 45% less likely to engage in regular physical activity compared to typically developing children. In contrast, children with other special health care needs, non-high impact developmental disabilities, or high-impact development disabilities were 8%, 15%, and 37% less likely to engage in regular physical activity compared to typically developing children, respectively. As children with Down syndrome have high rates of obesity(Bertapelli et al., 2016) and given that physical fitness and physical activity have been shown to influence physical and cognitive function in this population,(Chen, Ringenbach, Crews,

Kulinna, & Amazeen, 2015; Cowley et al., 2010; Ptomey et al., 2018) there is a great need for identifying the unique barriers to physical activity in children with Down syndrome and efforts to promote greater physical activity adoption.

In the present study, children with Down syndrome were less likely to participate in sports, with only 43% participating in sports relative to ~70% for typically developing children. Prior studies have reported that children with intellectual disability (not exclusive to Down syndrome) participate less often and less frequently in physical activity-based recreational activity relative to their typically developing peers (Chien, Rodger, & Copley, 2017; Kaljaca, Ducic, & Cvijetic, 2018; Shields, King, Corbett, & Imms, 2014). Thus, the present work confirms these previous findings for the first time in a sample of children with Down syndrome and are of concern given the documented benefits of sports participation, including improved self-efficacy, mood, and social competence (Hoogsteen & Woodgate, 2010; Ozer et al., 2012). Nonetheless, the observed findings are not surprising given the documented barriers to sports participation in this population including lack of access to inclusive sports programs, recreational facilities, and coaches with training or experience in adapted sport/physical activity instruction, lack of motor and social proficiency, and the high need for support from parents, peers, or service providers in order to participate (Kaljaca et al., 2018; McGarty & Melville, 2018).

Previous research suggests that children with Down syndrome spend more time sedentary relative to their typically developing peers (Matute-Llorente et al., 2013a, 2013b). Again, however, these studies are limited by small sample sizes and minimal covariate adjustment. Further, as sedentary time was ascertained via accelerometry, it is unclear what types of sedentary behavior children with Down syndrome typically engage it more often relative to their peers. Such information could be helpful for the development of more targeted sedentary interventions in this population. In the present study, children with Down syndrome were more likely to watch high volumes of TV compared to typically developing children; but no differences were observed for electronic device use. It should be acknowledged that the results for TV viewing were not statistically significant after accounting for general health; suggestive that differences in physical health may account for the observed differences in TV viewing comparing

children with Down syndrome to typically developing children. Nonetheless, this finding suggests that reductions in TV viewing and replacement with either physical activity or less passive and more mentally-active sedentary behaviors (e.g. reading)(Hallgren et al., 2018) that require greater levels of cognitive stimulation and engagement (if physical health precludes more activity) may be warranted in children with Down syndrome.

This study has several limitations. First, all NSCH data, including physical activity and sedentary behavior measures, were assessed by parental report mostly entailing one-item questions for a given topic. As such, there is a likelihood of recall bias and measurement error. Notably, as children typically perform sporadic movements that are brief in duration and varied in activity type, the assessment of physical activity in children via questionnaire is challenging and prone to measurement error. Parental reports of physical activity may be further prone to measurement error because parents may be unable to accurately quantify physical activity levels during school or other times away from the home. Thus, some caution is warranted when interpreting these results. Nonetheless, these findings confirm initial reports that accelerometer-measured physical activity levels were lower in children with Down syndrome relative to their typically developing peers (Matute-Llorente et al., 2013a, 2013b). Future population-based studies that utilize accelerometers to measure physical activity may still be needed to confirm these findings. Second, as a sample survey, the NSCH is subject to non-response bias. Third, the survey nature of the NSCH precluded medical professional confirmation of a child having a special health care need. Nor was severity for most conditions documented. Nonetheless, we adjusted for parental report of general health to account for potential differences in health condition severity. Finally, the sample size of children in the NSCH with Down syndrome is relatively small, albeit still comprising one of the largest samples to date to examine physical activity/sedentary behavior levels in this population. The small sample size precluded use of the NSCH sample weights. As such, the reported results are not nationally representative and may have limited generalizability.

In conclusion, in a large national survey of children in the US, children with Down syndrome were less likely to engage in regularly physical activity compared to typically developing children and

had the lowest likelihood among all subgroups of children with other developmental disabilities and special healthcare needs. There is a dearth of published interventions and programs targeting physical activity in populations with intellectual disabilities (Pitchford, Dixon-Ibarra, & Hauck, 2018). Thus, the present findings underscore an urgent need for researchers, health organizations, community groups, and funding agencies to design and support health promotion programs for children with Down syndrome.

REFERENCES

Atkin, A. J., Gorely, T., Biddle, S. J., Marshall, S. J., & Cameron, N. (2008). Critical hours: physical activity and sedentary behavior of adolescents after school. *Pediatric Exercise Science, 20*(4), 446-456.

Baquet, G., van Praagh, E., & Berthoin, S. (2003). Endurance training and aerobic fitness in young people. *Sports Medicine, 33*(15), 1127-1143. doi:10.2165/00007256-200333150-00004

Bertapelli, F., Pitetti, K., Agiovlasitis, S., & Guerra-Junior, G. (2016). Overweight and obesity in children and adolescents with Down syndrome-prevalence, determinants, consequences, and interventions: A literature review. *Research in Developmental Disabilities, 57*, 181-192. doi:10.1016/j.ridd.2016.06.018

Bethell, C. D., Read, D., Stein, R. E., Blumberg, S. J., Wells, N., & Newacheck, P. W. (2002). Identifying children with special health care needs: development and evaluation of a short screening instrument. *Ambulatory Pediatrics, 2*(1), 38-48.

Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Annals of Internal Medicine, 162*(2), 123-132. doi:10.7326/M14-1651

Boulet, S. L., Boyle, C. A., & Schieve, L. A. (2009). Health care use and health and functional impact of developmental disabilities among US children, 1997-2005. *Archives of Pediatrics & Adolescent Medicine, 163*(1), 19-26. doi:10.1001/archpediatrics.2008.506

Chen, C. C., Ringenbach, S. D., Crews, D., Kulinna, P. H., & Amazeen, E. L. (2015). The association between a single bout of moderate physical activity and executive function in

young adults with Down syndrome: a preliminary study. *Journal of Intellectual Disability Research, 59*(7), 589-598. doi:10.1111/jir.12163

Chien, C. W., Rodger, S., & Copley, J. (2017). Differences in patterns of physical participation in recreational activities between children with and without intellectual and developmental disability. *Research in Developmental Disabilities, 67*, 9-18. doi:10.1016/j.ridd.2017.05.007

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*: Routledge.

Cowley, P. M., Ploutz-Snyder, L. L., Baynard, T., Heffernan, K., Jae, S. Y., Hsu, S., . . . Fernhall, B. (2010). Physical fitness predicts functional tasks in individuals with Down syndrome. *Medicine & Science in Sports & Exercise, 42*(2), 388-393. doi:10.1249/MSS.0b013e3181b07e7a

Fernandes, R. A., & Zanesco, A. (2010). Early physical activity promotes lower prevalence of chronic diseases in adulthood. *Hypertension Research, 33*(9), 926-931. doi:10.1038/hr.2010.106

Fox, B., Moffett, G. E., Kinnison, C., Brooks, G., & Case, L. E. (2019). Physical Activity Levels of Children With Down Syndrome. *Pediatric Physical Therapy, 31*(1), 33-41. doi:10.1097/PEP.0000000000000556

Frey, G. C., Stanish, H. I., & Temple, V. A. (2008). Physical activity of youth with intellectual disability: review and research agenda. *Adapted Physical Activity Quarterly, 25*(2), 95-117.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., . . . American College of Sports, M. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory,

musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine & Science in Sports & Exercise, 43*(7), 1334-1359. doi:10.1249/MSS.0b013e318213fefb

Hallgren, M., Owen, N., Stubbs, B., Zeebari, Z., Vancampfort, D., Schuch, F., . . . Trolle Lagerros, Y. (2018). Passive and mentally-active sedentary behaviors and incident major depressive disorder: A 13-year cohort study. *Journal of Affective Disorders, 241*, 579-585. doi:10.1016/j.jad.2018.08.020

Harrell, J. S., Pearce, P. F., Markland, E. T., Wilson, K., Bradley, C. B., & McMurray, R. G. (2003). Assessing physical activity in adolescents: common activities of children in 6th-8th grades. *Journal of the American Academy of Nurse Practitioners, 15*(4), 170-178.

Hoogsteen, L., & Woodgate, R. L. (2010). Can I play? A concept analysis of participation in children with disabilities. *Physical & Occupational Therapy in Pediatrics, 30*(4), 325-339. doi:10.3109/01942638.2010.481661

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 40. doi:10.1186/1479-5868-7-40

Kaljaca, S., Ducic, B., & Cvijetic, M. (2018). Participation of children and youth with neurodevelopmental disorders in after-school activities. *Disability and Rehabilitation*, 1-13. doi:10.1080/09638288.2018.1457092

Mantovani, A. M., de Lima, M. C. S., Gobbo, L. A., Ronque, E. R. V., Romanzini, M., Turi-Lynch, B. C., . . . Fernandes, R. A. (2018). Adults Engaged in Sports in Early Life Have Higher Bone Mass Than Their Inactive Peers. *Journal of Physical Activity and Health, 15*(7), 516-522. doi:10.1123/jpah.2017-0366

Matute-Llorente, A., Gonzalez-Aguero, A., Gomez-Cabello, A., Vicente-Rodriguez, G., & Casajus, J. A. (2013a). Decreased levels of physical activity in adolescents with down syndrome are related with low bone mineral density: a cross-sectional study. *BMC Endocrine Disorders, 13*, 22. doi:10.1186/1472-6823-13-22

Matute-Llorente, A., Gonzalez-Aguero, A., Gomez-Cabello, A., Vicente-Rodriguez, G., & Casajus, J. A. (2013b). Physical activity and cardiorespiratory fitness in adolescents with Down syndrome. *Nutricion Hospitalria, 28*(4), 1151-1155. doi:10.3305/nh.2013.28.4.6509

McGarty, A. M., & Melville, C. A. (2018). Parental perceptions of facilitators and barriers to physical activity for children with intellectual disabilities: A mixed methods systematic review. *Research in Developmental Disabilities, 73*, 40-57. doi:10.1016/j.ridd.2017.12.007

Melville, C. A., Cooper, S. A., McGrother, C. W., Thorp, C. F., & Collacott, R. (2005). Obesity in adults with Down syndrome: a case-control study. *Journal of Intellectual Disability Research, 49*(Pt 2), 125-133. doi:10.1111/j.1365-2788.2004.00616.x

Mik, G., Gholve, P. A., Scher, D. M., Widmann, R. F., & Green, D. W. (2008). Down syndrome: orthopedic issues. *Current Opinion in Pediatrics, 20*(1), 30-36. doi:10.1097/MOP.0b013e3282f35f19

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjostrom, M. (2008). Physical fitness in childhood and adolescence: a powerful marker of health. *International Journal of Obesity (Lond), 32*(1), 1-11. doi:10.1038/sj.ijo.0803774

Ozer, D., Baran, F., Aktop, A., Nalbant, S., Aglamis, E., & Hutzler, Y. (2012). Effects of a Special Olympics Unified Sports soccer program on psycho-social attributes of youth

with and without intellectual disability. *Research in Developmental Disabilities, 33*(1), 229-239. doi:10.1016/j.ridd.2011.09.011

Palve, K. S., Pahkala, K., Magnussen, C. G., Koivistoinen, T., Juonala, M., Kahonen, M., . . . Raitakari, O. T. (2014). Association of physical activity in childhood and early adulthood with carotid artery elasticity 21 years later: the cardiovascular risk in Young Finns Study. *Journal of the American Heart Association, 3*(2), e000594. doi:10.1161/JAHA.113.000594

Parker, S. E., Mai, C. T., Canfield, M. A., Rickard, R., Wang, Y., Meyer, R. E., . . . National Birth Defects Prevention, N. (2010). Updated National Birth Prevalence estimates for selected birth defects in the United States, 2004-2006. *Birth Defects Research Part A: Clinincal and Molecular Teratology, 88*(12), 1008-1016. doi:10.1002/bdra.20735

Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., Galuska, D. A., . . . Olson, R. D. (2018). The Physical Activity Guidelines for Americans. *JAMA, 320*(19), 2020-2028. doi:10.1001/jama.2018.14854

Pitchford, E. A., Dixon-Ibarra, A., & Hauck, J. L. (2018). Physical Activity Research in Intellectual Disability: A Scoping Review Using the Behavioral Epidemiological Framework. *American Journal on Intellectual and Develpomental Disabilities, 123*(2), 140-163. doi:10.1352/1944-7558-123.2.140

Pitetti, K., Baynard, T., & Agiovlasitis, S. (2013). Children and adolescents with Down syndrome, physical fitness and physical activity. *Journal of Sport and Health Science, 2*(1), 47-57.

Presson, A. P., Partyka, G., Jensen, K. M., Devine, O. J., Rasmussen, S. A., McCabe, L. L., & McCabe, E. R. (2013). Current estimate of Down Syndrome population prevalence in the

United States. *The Journal of Pediatrics, 163*(4), 1163-1168. doi:10.1016/j.jpeds.2013.06.013

Ptomey, L. T., Szabo, A. N., Willis, E. A., Gorczyca, A. M., Greene, J. L., Danon, J. C., & Donnelly, J. E. (2018). Changes in cognitive function after a 12-week exercise intervention in adults with Down syndrome. *Disability and Health Journal, 11*(3), 486-490. doi:10.1016/j.dhjo.2018.02.003

Roizen, N. J., & Patterson, D. (2003). Down's syndrome. *The Lancet, 361*(9365), 1281-1289.

Ruiz, J. R., Castro-Pinero, J., Artero, E. G., Ortega, F. B., Sjostrom, M., Suni, J., & Castillo, M. J. (2009). Predictive validity of health-related fitness in youth: a systematic review. *British Journal of Sports Medicine, 43*(12), 909-923. doi:10.1136/bjsm.2008.056499

Sallis, J. F. (1991). Self-report measures of children's physical activity. *Journal of School Health, 61*(5), 215-219.

Schieve, L. A., Boulet, S. L., Kogan, M. D., Van Naarden-Braun, K., & Boyle, C. A. (2011). A population-based assessment of the health, functional status, and consequent family impact among children with Down syndrome. *Disability and Health Journal, 4*(2), 68-77. doi:10.1016/j.dhjo.2010.06.001

Shields, N., King, M., Corbett, M., & Imms, C. (2014). Is participation among children with intellectual disabilities in outside school activities similar to their typically developing peers? A systematic review. *Developmental Neurorehabilitation, 17*(1), 64-71. doi:10.3109/17518423.2013.836256

Sirard, J. R., & Pate, R. R. (2001). Physical activity assessment in children and adolescents. *Sports Medicine, 31*(6), 439-454. doi:10.2165/00007256-200131060-00004

Strasburger, V. C., Hogan, M. J., Mulligan, D. A., Ameenuddin, N., Christakis, D. A., Cross, C., . . . McCarthy, C. (2013). Children, adolescents, and the media. *Pediatrics, 132*(5), 958-961.

Tremblay, M. S., Carson, V., & Chaput, J. P. (2016). Introduction to the Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Applied Physiology, Nutrition, and Metabolism, 41*(6 Suppl 3), iii-iv. doi:10.1139/apnm-2016-0203

Utter, J., Neumark-Sztainer, D., Jeffery, R., & Story, M. (2003). Couch potatoes or french fries: are sedentary behaviors associated with body mass index, physical activity, and dietary behaviors among adolescents? *Journal of the American Dietetic Association, 103*(10), 1298-1305.

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: the evidence. *CMAJ, 174*(6), 801-809. doi:10.1503/cmaj.051351

Whitt-Glover, M. C., O'Neill, K. L., & Stettler, N. (2006). Physical activity patterns in children with and without Down syndrome. *Pediatric Rehabilitation, 9*(2), 158-164. doi:10.1080/13638490500353202

FIGURE LEGEND

Figure 1: Frequency of regular physical activity, sports participation, TV viewing ≥2 h/day, and electronic device use ≥2 h/day among children with Down syndrome, children with other developmental disabilities or special health care needs, and typically developing children.

Table 1. Characteristics of Children with Down syndrome, Children with Other Special Health Care Needs, and Typically Developing Children in the 2016-2017 National Survey of Children's Health.

Characteristic	**Typical** *(n=36,539)*	**Other Special Health Care Needs**[a] *(n=10,025)*	**Developmental Disability without High Functional Impact**[b] *(n=1,360)*	**Developmental Disability with High Functional Impact**[c] *(n=2,165)*	**Down syndrome** *(n=102)*
Age (years)	12.0 (3.5)	12.5 (3.3)	11.9 (3.4)	12.1 (3.3)	12.5 (2.9)
Male (%)	49.4	52.0	61.6[e]	69.4[e]	52.0
Race (%)					
White	77.2	78.8	75.9	76.4	82.4
Black	6.1	7.4	9.3	8.0	2.0[e]
Other	16.8	13.8	14.9	15.6	15.7
Hispanic Ethnicity (%)	11.4	9.8	11.8	11.9	16.7
Educational achievement (%)[d]					
< High school	2.4	1.9	2.5	3.1	3.9
High school	13.3	12.1	18.7	16.1	18.6
Some college or Associate's degree	22.9	24.4	27.3	28.2	20.6
≥College degree	61.2	61.6	51.4	52.5	56.7
Born outside US (%)	4.1	2.8	4.6	2.8	4.0
Federal Poverty Level					
0-199%	24.5	26.2	36.6[e]	35.8[e]	40.2[e]
200-299%	16.5	15.6	19.1	16.5	11.8
300-399%	15.6	15.2	13.3	15.0	15.7
≥400%	43.3	43.0	31.0[e]	32.7[e]	32.4[e]
General Health (%)					
Excellent	75.7	44.3[e]	31.8[e]	29.4[e]	18.6[e]
Very Good	20.4	37.3[e]	36.7[e]	36.4[e]	38.2[e]
Good	3.7	15.7[e]	24.0[e]	24.8[e]	37.3[e]
Fair/Poor	0.3	2.7[e]	7.5[e]	9.4[e]	5.9[e]

Data presented as mean (SD) or percent.

[a]Defined as child with special health care need according to Children with Special Health Care Needs Screener without developmental or intellectual disability.

[b]Defined as child with developmental or intellectual disability other than Down syndrome, autism, cerebral palsy, visual impairment, or hearing impairment.

[c]Defined as child with autism, cerebral palsy, visual impairment, or hearing impairment.

[d]Highest level of education among anyone living in household.

[e]Effect size (Cohen's d or Cohen's h) ≥0.20 comparing mean or percent vs. typical children.

Table 2. Odds Ratio of Regular Physical Activity, Sports Participation, and Sedentary Behaviors Among Children with Down syndrome or Other Special Health Care Needs Versus Typical Children in the 2016-2017 National Survey of Children's Health

Physical Activity/Sedentary Behavior Characteristic	**Typical** *(n=36,539)*	**Other Special Health Care Needs**[a] *(n=10,025)*	**Developmental Disability without High Functional Impact**[b] *(n=1,360)*	**Developmental Disability with High Functional Impact**[c] *(n=2,165)*	**Down syndrome** *(n=102)*
Regular MVPA[d]					
Unadjusted	1.00 (ref)	0.73 (0.70, 0.77)	0.64 (0.57, 0.71)	0.48 (0.44, 0.53)	0.37 (0.25, 0.56)
Model 1[e]	1.00 (ref)	0.74 (0.71, 0.78)	0.62 (0.56, 0.70)	0.45 (0.41, 0.50)	0.37 (0.24, 0.56)
Model 2[f]	1.00 (ref)	0.92 (0.87, 0.96)	0.85 (0.75, 0.95)	0.63 (0.57, 0.69)	0.55 (0.36, 0.84)
Sport Participation	1.00 (ref)				
Unadjusted	1.00 (ref)	0.73 (0.69, 0.76)	0.39 (0.35, 0.44)	0.24 (0.22, 0.27)	0.33 (0.22, 0.49)
Model 1[e]	1.00 (ref)	0.71 (0.67, 0.74)	0.41 (0.36, 0.46)	0.23 (0.21, 0.25)	0.34 (0.23, 0.52)
Model 2[f]	1.00 (ref)	0.84 (0.80, 0.89)	0.53 (0.47, 0.59)	0.30 (0.27, 0.33)	0.48 (0.32, 0.74)
Television Viewing >2 h/day	1.00 (ref)				
Unadjusted	1.00 (ref)	1.29 (1.22, 1.36)	1.53 (1.35, 1.73)	1.90 (1.73, 2.09)	1.82 (1.18, 2.79)
Model 1[e]	1.00 (ref)	1.25 (1.18, 1.32)	1.33 (1.16, 1.51)	1.62 (1.47, 1.79)	1.77 (1.14, 2.75)
Model 2[f]	1.00 (ref)	1.08 (1.02, 1.15)	1.09 (0.95, 1.24)	1.31 (1.18, 1.45)	1.35 (0.87, 2.11)
Electronic Device Use >2 h/day	1.00 (ref)				
Unadjusted	1.00 (ref)	1.43 (1.36, 1.50)	1.27 (1.13, 1.43)	1.44 (1.31, 1.57)	1.04 (0.67, 1.60)
Model 1[e]	1.00 (ref)	1.36 (1.29, 1.43)	1.29 (1.14, 1.47)	1.43 (1.29, 1.58)	0.97 (0.61, 1.54)
Model 2[f]	1.00 (ref)	1.21 (1.15, 1.28)	1.09 (0.96, 1.25)	1.20 (1.08, 1.33)	0.77 (0.48, 1.22)

Data presented as odds ratio (95% confidence interval).

[a]Defined as child with special health care need according to Children with Special Health Care Needs Screener without developmental or intellectual disability.

[b]Defined as child with developmental or intellectual disability other than Down syndrome, autism, cerebral palsy, visual impairment, or hearing impairment.

[c]Defined as child with autism, cerebral palsy, visual impairment, or hearing impairment.

[d]Defined as exercise, sport, or physical activity for 60 minutes on ≥4 days per week.

[e]Adjusted for age, sex, race, Hispanic ethnicity, educational achievement, born outside United States, and poverty level.

[f]Adjusted for covariates in Model 1 plus general health.