JIDR

Changes in objectively measured physical activity in adolescents with Down syndrome: the UP&DOWN Longitudinal Study.

Journal:	*Journal of Intellectual Disability Research*
Manuscript ID	JIDR-12-2015-0324-OM.R2
Manuscript Type:	Original Manuscripts
Keywords:	prospective study, adolescents, Intellectual Disability, physical activity

SCHOLARONE™
Manuscripts

For Peer Review

Changes in objectively measured physical activity in adolescents with Down syndrome: the UP&DOWN Longitudinal Study.

For Peer Review

Abstract

Background: It is a priority to understand physical activity behaviour over time is a priority in Down syndrome population in order to design and promote succesfull interventions to maintain or increase levels of physical activity. We aimed to study 1-year and 2-year change in objectively measured physical activity among a relatively large sample of adolescents with Down syndrome.

Methods: This study comprised a total of 99 adolescents with Down syndrome (38 females) aged from11 to 20 years old at baseline. Participants with valid accelerometer data at baseline and at least one of the follow-up visits were included in the analysis.

Results: Overall, levels of physical activity observed in adolescents with Down syndrome declined from baseline to follow-ups, but these changes were not significant (all $p>0.05$). Moderate-to-moderately high tracking of physical activity was observed in adolescents with Down syndrome (all $p<0.001$). Youths who met physical activity guidelines at baseline demonstrated a greater decline in physical activity in 1-year and 2-years change ($p<0.05$), although they were also more likely to meet physical activity guidelines at 1-and-2 years follow-ups ($p<0.05$).

Conclusions: Adolescents with Down syndrome do not change their levels of physical activity at 2-year follow-ups, but those who met physical activity guidelines presented stronger declines in physical activity over time.

Keyword: prospective study, adolescents, intellectual disability, physical activity.

For Peer Review

Introduction

The health benefits of physical activity on chronic diseases throughout the lifespan are well established (Lee et al. 2012). Based on this knowledge, encouraging adolescents to engage in at least 60 minutes per day of moderate-to-vigorous physical activity is a public health priority (Physical Activity Guidelines Advisory Committee 2008; Tremblay et al. 2011). Since today's adolescents are the adults of tomorrow, there is a need to understand how physical activity changes through this period of life.

Recent findings among adolescents with Down syndrome suggest that this population is considerably less active than their counterparts, with or without intellectual disabilities (Phillips & Holland 2011; Matute-Llorente et al. 2013). It is known that people with Down syndrome often present health problems associated to the respiratory, circulatory and musculoskeletal systems (Roizen & Patterson 2003), including poor motor skills which may contribute to limit their physical activity (Pitteti et al. 2013). Furthermore, the life expectancy of people with Down syndrome has increased by more than 40 years in recent decades (Bittles & Glasson 2004; Coppus 2013), which clearly contribute to a greater exposure to chronic diseases. Therefore, understanding physical activity behaviour over time is a priority in this population, in order to design and promote succesfull interventions to maintain or increase physical activity.

Compared to subjective tools (e.g. questionnaires), which are difficult to administer in this population due to their cognitive limitations, objective measurements of physical activity are less prone to bias and particularly crucial when assessing physical activity among people who have intellectual disabilities. However, available evidence on levels of objectively measured physical activity in adolescents with Down syndrome derives from cross-sectional studies (Izquierdo-Gomez et al. 2014; McGarty et al. 2014; Pitteti et al. 2013). Recent studies have reported that adolescent males with Down syndrome were more active than adolescent

For Peer Review

females and physical activity decreases when adolescents get older (Esposito et al. 2012; Izquierdo-Gomez et al., 2014).

In addition, longitudinal studies that have used objective method have usually measured changes in physical activity in adolescents without intellectual disabilities rather than Down syndrome population (Dumith, Gigant, Domingues, & Kohl, 2011; Brooke, Atkin, Corder, Ekelund, & van Sluijs, 2016). The most comprehensive longitudinal study using objective reported in adolescents without intellectual disabilities observed that physical activity markedly declines across the years, mainly in males and at younger ages (Ortega et al. 2013), but little is know about physical activity changes in adolescents with Down syndrome, and even less is know in longitudinal changes in levels objectively measured to confirm whether adolescents with Down syndrome present similar patterns. Therefore, the aim of this study was to examine 1-year and 2-year longitudinal change in objectively measured physical activity among a relatively large sample of adolescents with Down syndrome.

For Peer Review

Methods

Study design and sample

The UP&DOWN study is a 3-years longitudinal study designed to assess the impact over time of physical activity and sedentary behaviour on health indicators (i.e. physical fitness, metabolic and cardiovascular disease risk factors, inflammation-immunity biomarkers and mental health), as well as to identify the psycho-environmental and genetic determinants of physical activity in Spanish children and adolescents with and without Down syndrome. Full methodological details of the study were described elsewhere [redacted]

Baseline data was collected in 2011-2012, the first follow-up in 2012-2013, and the second follow-up in 2013-2014. Participants with valid accelerometer data at baseline and at least one of the follow-up visits were included in the analysis. A total of 61 males and 38 females, aged 11-20 years (15.9 ± 2.4 years), was the final sample for this study.

Participants were recruited from special education schools, associations and foundations for people with intellectual disabilities [redacted] All participants with Down syndrome had to meet two inclusion criteria: an intelligence quotient over 35 and no severe physical disabilities that may impede or interfere with physical activity (e.g. wheelchair users). Before participants took part in the UP&DOWN study, parents and institution supervisors were informed about the study characteristics, and then written consent was obtained. The study protocol was approved by the Ethics Committee of [redacted]

For Peer Review

Measurements

Physical activity. Physical activity was measured by ActiGraph accelerometer models GT1M, GT3X and GT3X+ (Actigraph TM, LLC, Pensacola, FL, US). These accelerometers are small, compact and lightweight monitors designed to detect vertical accelerations movements. Previous studies have demonstrated that there is strong agreement between outputs from the three Actigraph models (Robusto & Trost 2013; Vanhelst et al. 2012). Participants wore the accelerometer on the lower back, fitted with an elastic belt during waking hours for seven consecutive days and were instructed to remove them for bed times and water-based activities (Trost, Mclver, & Pate, 2005). Data were reintegrated into 10-second epochs before analysis (Cain et al. 2013). Non-wearing time was defined as period of 60 min of zero counts and an allowance for up to two consecutives minutes of <100 counts per minute (cpm) with the up/downstream 30 minutes consecutive of zero counts for period for detection of artifactual movements (Cain et al. 2013; Choi et al. 2011). Data were downloaded and analysed using the ActiLife software (v.6.8.0 Actigraph TM, Pensacola, FL, US). Inclusion criteria for the analyses were: (a) at least three days of valid data (b) and minimum of eight hours of registration per day (Cain et al. 2013).

Variables included in the present analyses were total physical activity, expressed cpm, moderate, vigorous and moderate-to-vigorous physical activity expressed in minutes per day. The time spent in each physical activity category was estimated using cut-points of 2,000 and 4,000 cpm for moderate and vigorous physical activity, respectively (Ruiz et al., 2011). These cut-points to define levels of physical activity are similar to those used in previous studies with European children and adolescents (Martinez-Gomez et al. 2010). Moderate-to-vigorous physical activity was also dichotomized into <60 min/days and ≥60 min/day, according to the current physical activity guidelines for youth (Physical Activity Guidelines Advisory Committee 2008).

For Peer Review

Statistical analysis

Descriptive characteristics of the study sample were presented as means and standard deviations. One-way analyse of variance (ANOVA) was used to examine differences in levels of physical activity by sex and age groups (those ≤ 16 years were considered younger adolescents and those ≥ 17 years were considered older adolescents) at baseline and follow-ups. We also estimated the between-group effect size (Cohen's *d*). According to Cohen's classification (Cohen, 1992), effect sizes are interpreted as follows: small ($d = 0.2$), moderate ($d = 0.5$) and large ($d = 0.8$). Paired t-tests segmented by sex and age groups were used to assess changes in levels of physical activity in an average week. We also examined changes in physical activity for those adolescents who meet physical activity guidelines using paired t-tests segmented for compliance of physical activity guidelines at baseline. Additionally, we also examine changes in physical activity in weekdays (Monday to Friday) and weekend days (Saturday and Sunday) for males and females and younger and older adolescents. The tracking of levels of physical activity was examined using Pearson's correlation segmented for sex and age groups. According to Malina et al. (1996), correlations are interpreted as follows: <0.30, low; 0.30 to 0.60, moderate and >0.60, moderately-high. Finally, we also examine the likelihood of meeting physical activity guidelines between baseline and follow-ups using binary logistic regression. All statistical analyses were performed using IBM SPSS statistical software package (v.20.0, Chicago, IL, USA) for Macintosh, and the level of significance was set at $p<0.05$.

For Peer Review

Results

Descriptive characteristics of the whole sample and by sex at baseline and follow-ups are displayed in **Table 1**. **Table 2** shows objectively measured physical activity of the participants at baseline and in each follow-up visit in an average week. Male participants engaged in more vigorous physical activity than females at baseline, as well as in total and vigorous physical activity at 2-years follow-up ($p<0.05$). Specifically, medium effect was observed in vigorous physical activity at baseline and vigorous physical activity at 2-years follow-up (d=0,41, 0,48 and 0,51, respectively). There were no differences in levels of physical activity by age at baseline and follow-ups measurements. Results were similar when levels of physical activity were examined during week and weekend days by age, even though sex-specific differences were principally found during weekend days (Supplementary Tables 1-2).

Table 3 shows changes in objectively measured physical activity of participants in an average week. Changes in physical activity were examined across the total sample, in both sexes and both age groups. Overall, levels of physical activity observed in adolescents with Down syndrome declined from baseline to 1-year and 2-years follow-ups, but these changes were not significant (all $p>0.05$). Physical activity changes during week and weekend days were examined by sex and age, presenting virtually identical results (Supplementary Tables 3-4). **Table 4** shows the tracking of levels of physical activity from baseline to follow-up visits. Pearson correlation coefficients for all levels of physical activity were moderate-to-moderately high at 1-and 2-years follow-ups, ranging from 0.453 to 0.847 (all $p<0.001$).

In the total sample, we observed that only 22 (22%) of adolescents with Down syndrome met physical activity guidelines at baseline, 21 (23%) at 1-year follow-up, and 15 (17%) in the last follow-up visit. We analysed changes in objectively measured physical activity according to group of compliers (< 60 min/day) and non-compliers (≥ 60 min/day) of

For Peer Review

physical activity guidelines at baseline (**Table 5**). Those adolescents who met physical activity guidelines at baseline significantly decreased their levels of physical activity after 1-year and 2-years change (p<0.05), while adolescents who did not meet physical activity guidelines at baseline maintained their levels of physical activity.

Lastly, binary logistic regression analysis was employed to determine the likelihood of meeting physical activity guidelines (compliers vs. non-compliers) at baseline and follow-ups. This analysis showed that those adolescents who met physical activity guidelines at baseline were more likely to meet physical activity guidelines at 1-year (OR=10.5; 95% CI, 3.4-32.7) and 2-years follow-ups (OR=12.6; 95% CI, 3.5-44.6) than adolescents who did not meet physical activity guidelines at baseline.

For Peer Review

Discussion

This is the first study, to the best of our knowledge, to examine longitudinal changes in objectively measured physical activity in adolescents with Down syndrome. The main findings of the present study indicate that: (i) adolescents with Down syndrome presented no significant changes in their level of physical activity over 2-years study period (ii) moderate-to-moderately high tracking of physical activity was observed in adolescents with Down syndrome at 1-and 2-years follow-ups, and (iii) youths who met physical activity guidelines at baseline demonstrated a greater decline in physical activity in 1-year and 2-years change, although they were also more likely to meet physical activity guidelines after these periods. These results provide new evidence and valuable information about longitudinal changes in physical activity patterns over time in adolescents with Down syndrome.

Previous studies using accelerometers in adolescents with Down syndrome reported that they exhibit lower levels of physical activity compared to their counterparts with and without intellectual disabilities (Esposito et al. 2012; Matute-LLorente et al. 2013; Phillips & Holland 2011). The findings in cross-sectional design are limited; meaning further research with longitudinal data was required. For example, we previously reported in a cross-sectional study that adolescent males engaged in more physical activity than females on both during week and weekend days, as well as the younger group (11-14 years) engaged in more physical activity than the older groups (15-17 and 18-21 years) in this population (Izquierdo-Gomez et al. 2014). In this study, we found differences in results from the previous cross-sectional UP&DOWN study because of the cut-point used.

Declines in objectively measured physical activity during adolescence among males and females in populations without disabilities have been reported in the literature (Dumith et al. 2011; Ortega et al. 2013; Brooke et al., 2016). Specifically, Ortega et al. (2013) found that moderate-to-vigorous physical activity decreased 2.2 min/day in males and 0.8 min/day in

For Peer Review

females from adolescence to young adulthood. In contrast, the results of the present study indicate that the level of moderate-to-vigorous physical activity in males and females adolescents with Down syndrome decreased by 3.1 min/day and 2.3 min/day, respectively, when changes of physical activity levels at 2-years follow-up were examined, but these changes were not significant.

In addition, Ortega et al. (2013) reported a higher decline in levels of physical activity from adolescence to adulthood. Specifically, these authors estimated a decrease of 13 min/day from adolescence to young adulthood. We found a similarity trajectory of change by age in our study in adolescents with Down syndrome. Overall, the younger and older adolescents with Down syndrome decreased 2.6 min/day and 3.1 min/day their level of moderate-to-vigorous physical activity over 2-years change, but once again, these changes were not significant. However, discrepancies among studies could be due to our sample size and possible differences in the physical activity behaviour in both populations. Indeed, it is likely that the decline of physical activity in adolescents with Down syndrome is closely linked to biological, social and psychological factors, thus it would be interesting to develop longitudinal studies involving longer follow-up period. Given that adolescents with Down syndrome do not increase levels of physical activity and the decline in physical activity continues throughout the entire life course in general population (Sallis 2000), these results highlight the need for physical activity interventions in this population. In addition, the physical activity reduction observed in this study might have long-lasting effects on their health.

Patterns of physical activity during adolescence tend to track into adulthood. Likewise, it is expected that active children will also be active adults, which in turn will have a favourable effect on public health (Hallal et al. 2006; Telama 2009; Telama et al. 2005). Tracking of physical activity in adolescents without disabilities have been studied, but we are

For Peer Review

unaware of previous studies on the tracking of physical activity in youth with Down syndrome. Kristensen et al. (2008) reported small-to-moderate strength of tracking of objectively measured physical activity from 10-12 and 14-16 years old adolescents without disabilities (r=0.18 and 0.19 for males and females, respectively) but the tracking was higher after adjusting for random error due to day-to-day variation and within instrumental measurement error (r=0.53 and 0.48 for males and females, respectively). Our tracking results were of moderate-to-high magnitude (Malina 1996), showing that the tendency of adolescents with Down syndrome is to maintain their rank within a group over time.

Our study also revealed that those who met the physical activity guidelines at baseline presented greater declines in physical activity than those who did not, probably due to the fluctuations of physical activity over time, giving rise to so-called a phenomenon similar to 'regression to the mean' (Shephard 2003). These large declines in physical activity observed in those adolescents who initially met physical activity guidelines coupled with the maintenance of all levels of physical activity in those adolescents who did not meet physical activity guidelines over 2-years follow-ups cause for concern. This is because public health recommendations suggest that those who meet physical activity guidelines should continue being active and even, become more active over time as well as those who do not meet physical activity guidelines should slowly increase their levels of physical activity (Physical Activity Guidelines Advisory Committee 2008). Therefore, physical activity strategies in adolescents with Down syndrome should focus on helping to maintain levels of physical activity from those adolescents who meet physical activity guidelines and increase levels of physical activity from those adolescents who do not meet physical activity guidelines.

Special attention should be also paid to our results concerning the proportion of adolescents with Down syndrome who meet physical activity guidelines for young people. Some studies have shown that most people with Down syndrome do not achieve the current

For Peer Review

physical activity guidelines of at least 60 minutes of moderate-to-vigorous physical activity per day (Esposito et al. 2012) but the longitudinal nature of our current data allows us to investigate the effect of baseline physical activity on subsequent behaviour. Hence, we found that only 22% of adolescents with Down syndrome met physical activity guidelines at baseline, and this proportion was reduced to 17% in the last follow-up visit. Despite of these findings, those who met the physical activity guidelines at baseline were also more likely to meet physical activity guidelines at follow-ups. Taking into account the high tracking of physical activity, it is important to encourage children and adolescents to take part in regular physical activity in order to get active adults with a better chance of healthy lifestyle.

This study has some strength, including the relatively large and heterogeneous sample of adolescents with Down syndrome, the use of accelerometry and the inclusion of three data points (i.e. baseline, 1-year and 2-year follow-ups). However, this study also has limitations. The ActiGraph accelerometers cannot be worn during swimming activities and therefore physical activity may have been underestimated. Secondly, there is no consensus on the appropriate accelerometers cut-points to assess levels of physical activity in youth with Down syndrome. In addition, Down syndrome population might present an altered relationship between METs and activity-count rate during walking due to altered gait patterns (Cimolin et al. 2010; Kubo & Ulrich 2006; Ulrich et al. 2004, Agiovlasitis, McCubbin, Yun, Mpitsis & Pavol, 2009). This may influence the cut-point for identifying physical activity intensities (Agiovlasitis et al., 2011). Finally, further studies should continue to follow adolescents with Down syndrome for a longer period.

In summary, adolescents with Down syndrome do not change their levels of physical activity at 2-year follow-ups, but those who met physical activity guidelines presented stronger declines in physical activity over time. Our findings shed light on changes in levels of physical activity in youths with Down syndrome and provide valuable information for the

For Peer Review

planning of future interventions aimed at increasing physical activity in this population. More longitudinal studies over longer periods are needed to confirm these results.

For Peer Review

Reference

Agiovlasitis S., McCubbin J. A., Yun J., Mpitsos, G. & Pavol M. J. (2009) Effects of Down syndrome on three-dimensional motion during walking at different speeds. *Gait Posture* **30**, 345e50.

Agiovlasitis S., Motl R. W., Fahs C. A., Ranadive S. M., Yan H., Echols G. H., Rossow L. & Fernhall B. (2011) Metabolic rate and accelerometer output during walking in people with Down syndrome. *Medicine and Science in Sports and Exercise* **43**, 1322e7.

Bittles A. H. & Glasson E. J. (2004) Clinical, social, and ethical implications of changing life expectancy in Down syndrome. *Developmental Medicine & Child Neurology* **46**, 282-286.

Brooke H. L., Atkin A. J., Corder K., Ekelund U. & van Sluijs, E. M. (2016) Changes in time-segment specific physical activity between ages 10 and 14 years: A longitudinal observational study. *Journal of Science & Medicine in Sport* **19**, 29-34. doi: 10.1016/j.jsams.2014.10.003.

Cain K. L., Sallis J. F., Conway T. L., Van Dyck D. & Calhoon, L. (2013) Using accelerometers in youth physical activity studies: A Review of Methods. *Journal of Physical Activity & Health* **10**, 437-450.

Castro-Piñero, J., Carbonell-Baeza, A., Martinez-Gomez, D., Gómez-Martínez, S., Cabanas-Sánchez, V., Santiago, C.,…Marcos, A. (2014). Follow-up in healthy schoolchildren and in adolescents with DOWN syndrome: psycho-environmental and genetic determinants of physical activity and its impact on fitness, cardiovascular diseases, inflammatory biomarkers and mental health; the UP&DOWN Study. *BMC Public Health*, *14*, 400. doi: 10.1186/1471-2458-14-400.

For Peer Review

Choi L., Liu Z., Matthews C. E. & Buchowski M. S. (2011) Validation of Accelerometer Wear and Nonwear Time Classification Algorithm. *Medicine & Science in Sports & Exerise* **43**, 357-364. doi: 10.1249/MSS.0b013e3181ed61a3.

Cimolin V., Galli M., Grugni G., Vismara L., Albertini G., Rigoldi C. & Capodaglio, P. (2010) Gait patterns in Prader-Willi and Down syndrome patients. *Journal of Neuroengineering & Rehabilitation* **7**, 28. doi: 10.1186/1743-0003-7-28

Cohen, J. (1992) A power primer. *Psychological Bulletin* **112**, 155–159.

Coppus A. M. (2013). People with intellectual disability: what do we know about adulthood and life expectancy?. *Developmental Disabilities Research Reviews* **18**, 6-16. doi: 10.1002/ddrr.1123.

Dumith S. C., Gigante D. P., Domingues M. R. & Kohl H. W. (2011) Physical activity change during adolescence: a systematic review and a pooled analysis. *International Journal Epidemiology* **40**, 685-698. doi: 10.1093/ije/dyq272.

Esposito P. E, MacDonald M., Hornyak J. E. & Ulrich D. A. (2012) Physical activity patterns of youth with Down syndrome. *Intellectual & Developmental Disabilities* **50**, 109-119. doi: 10.1352/1934-9556-50.2.109

Hallal P. C., Victora C. G., Azevedo M. R. & Wells J. C. (2006) Adolescent physical activity and health: a systematic review. *Sports Medicine* **36**, 1019-1030.

Izquierdo-Gomez R., Martinez-Gomez D., Acha A., Veiga O. L., Villagra A. & Diaz-Cueto, M. (2014) Objective assessment of sedentary time and physical activity throughout the week in adolescents with Down syndrome. The UP & DOWN Study. *Research in Developmental Disabilities* **35**, 482-489. doi: 10.1016/j.ridd.2013.11.026.

For Peer Review

Kristensen P. L., Møller N. C., Korsholm L., Wedderkopp N., Andersen L. B. & Froberg, K. (2008) Tracking of objectively measured physical activity from childhood to adolescence: the European youth heart study. *Scandinavian Journal of Medicine in Science & Sports* **18**, 171-178.

Kubo M. & Ulrich B. (2006) Coordination of pelvis-hat (head, arms and trunk) in anterior-posterior and medio-lateral directions during treadmill gait in preadolescents with/without Down syndrome. *Gait Posture* **23**, 512e8.

Lee I. M., Shiroma E. J., Lobelo F., Puska P., Blair S. N. & Katzmarzyk P. T. (2012) Impact of Physical Inactivity on the World's Major Non-Communicable Diseases. *Lancet* **380**, 219–229.

Malina R. M. (1996) Tracking of physical activity and physical fitness across the lifespan. *Research Quaterly for Exercise & Sport* **67**, S48-57.

Martinez-Gomez D., Ruiz J. R., Ortega F. B., Veiga O. L., Moliner-Urdiales D., Mauro B. et al. (2010) Recommended levels of physical activity to avoid an excess of body fat in European adolescents: the HELENA Study. *American Journal of Preventive Medicine* **39**, 203-211. doi: 10.1016/j.amepre.2010.05.003.

Matute-Llorente A., González-Agüero A., Gómez-Cabello A., Vicente-Rodríguez G. & Casajús J. A. (2013) Physical activity and cardiorespiratory fitness in adolescents with Down syndrome. *Nutrición Hospitalaria* **28**, 1151-1155. doi: 10.3305/nh.2013.28.4.6509.

McGarty A. M., Penpraze V. & Melville C. A. (2014) Accelerometer use during field-based physical activity research in children and adolescents with intellectual disabilities: a

For Peer Review

systematic review. *Research in Developmental Disabilities* **35**, 973-981. doi: 10.1016/j.ridd.2014.02.009.

Ortega F. B., Konstabel K., Pasquali E., Ruiz J. R., Hurtig-Wennlof A., Lof M. et al. (2013) Objectively measured physical activity and sedentary time during childhood, adolescence and young adulthood: a cohort study. *PloS ONE* **8**, e60871.

Phillips A. C. & Holland A. J. (2011) Assessment of objectively measured physical activity levels in individuals with intellectual disabilities with and without Down´s syndrome. *PloS ONE* **6**, e28618.

Physical Activity Guidelines Advisory Committee. (2008) *Physical Activity Guidelines Advisory Committee Report.* Washington: Department of Health and Human Services.

Pitteti K., Baynard T. & Agiovlasitis S. (2012) Children and adolescents with Down syndrome, physical fitness and physical activity. *Journal of Sport & Health Science* **2**, 47-57. doi: 10.1016/j.jshs.2012.10.004.

Robusto K. M. & Trost S. G. (2013) Comparison of three generations of ActiGraphTM activity monitors in children and adolescents. *Journal of Sports Sciences* **30**, 1429-1435.

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

Ruiz J. R., Ortega F. B., Martínez-Gómez D., Labayen I., Moreno L. A., De Bourdeaudhuij I., et al. (2011) Objectively measured physical activity and sedentary time in European adolescents: the HELENA study. *American Journal of Epidemiology* **174**, 173-84. doi: 10.1093/aje/kwr068.

For Peer Review

Sallis J. F. (2000) Age-related decline in physical activity: a synthesis of human and animal studies. *Medicine & Science in Sports & Exercise* **32**, 1598–1600.

Shephard R. J. (2003) Regression to the mean. A threat to exercise science?. *Sports Medicine* **33**, 575-584.

Telama R. (2009) Tracking of physical activity from childhood to adulthood: a review. *Obesity Facts* **2**, 187-195. doi: 10.1159/000222244.

Telama R., Yang X., Viikari J., Välimäki I., Wanne O. & Raitakari, O. (2005) Physical activity from childhood to adulthood: a 21-year tracking study. *American Journal of Preventive Medicine* **28**, 267-273.

Tremblay M. S., Leblanc A. G., Janssen I., Kho M. E., Hicks A., Murumets, K. et al. (2011) Canadian sedentary behaviour guidelines for children and youth. *Applied Physiology, Nutrition & Metabolism* **36**, 59-71. doi: 10.1139/H11-012.

Trost S. G., McIver K. L. & Pate R. R. (2005) Conducting accelerometer-based activity assessments in field-based research. *Medicine & Science in Sports & Exercise* **37**, S531-43.

Ulrich B. D., Haehl V., Buzzi U. H., Kubo M. & Holt K. G. (2004) Modeling dynamic resource utilization in populations with unique constraints: preadolescents with and without Down syndrome. *Human Movement Science* **23**, 133e56.

Vanhelst J., Mikulovic J., Bui-Xuan G., Dieu O., Biondeau T., Fardy P. & Béghin L. (2012) Comparison of two Actigraph accelerometer generations in the assessment of physical activity in free living conditions. *BMC Research Notes* **5**, 187. doi: 10.1186/1756-0500-5-187.

For Peer Review

Table 1.Participants characteristics at baseline and follow-up

	Baseline (2011-2012)				Follow up (2012-2013)				Follow up (2013-2014)			
	All	Males	Females	*p*	All	Males	Females	*p*	All	Males	Females	*p*
n	99	61	38		92	56	36		88	56	32	
Age (years)	15.9 ± 2.4	16.1 ± 2.5	15.6 ± 2.2	0.284	16.8 ± 2.5	17.1 ± 2.5	16.7 ± 2.2	0.461	17.8 ± 2.4	18.1 ± 2.5	17.5 ± 2.1	0.366
Weight (kg)	52.7 ± 12.1	54.6 ± 13.5	49.7 ± 8.8	0.054	54.1 ± 11.5	56.1 ± 13.1	50.7 ± 7.5	**0.011**	57.1 ± 11.9	59.4 ± 12.3	53.1 ± 10.0	**0.015**
Height (cm)	148.3 ± 9.5	151.6 ± 9.8	143.0 ± 5.9	**<0.001**	149.3 ± 9.1	153.7 ± 8.2	143.8 ± 5.9	**<0.001**	150.8 ± 8.5	154.8 ± 6.8	143.7 ± 6.1	**<0.001**
Body mass index (kg/m^2)	23.8 ± 4.2	23.5 ± 4.1	24.4 ± 4.2	0.289	24.1 ± 4.1	23.8 ± 4.2	24.6 ± 3.8	0.413	25.0 ± 4.2	24.6 ± 4.0	25.7 ± 4.6	0.264

Values are mean ± SD or percentages. Statistically significant values are showed in bold. $^{*}P$ <0.05 denotes statistical significance between males and females.

For Peer Review

Table 2. Objectively measured physical activity (PA) of adolescents with Down syndrome in each follow-up visit in an average week

		Sex		Age group	
	All	Males	Females	Younger	Older
Baseline					
n	99	61	38	53	46
Total PA (counts/min)	355.3 ± 138.9	372.2 ± 150.8	328.3 ± 113.9	366.9 ± 131.2	342.0 ± 147.5
Moderate PA (min/day)	34.0 ± 11.8	34.5 ± 12.0	33.1 ± 11.6	34.5 ± 12.3	33.4 ± 11.4
Vigorous PA (min/day)	12.3 ± 10.0	**14.0 ± 11.6**	**10.0 ± 5.6**	12.1 ± 8.3	12.5 ± 11.7
Moderate-to-vigorous PA (min/day)	46.3 ± 19.5	48.5 ± 21.0	42.7 ± 16.3	46.6 ± 18.5	45.9 ± 19.5
1-year follow-up					
n	92	56	36	48	44
Total PA (counts/min)	344.1 ± 132.5	356.2 ± 143.7	325.2 ± 112.4	352.0 ± 127.7	335.5 ± 138.6
Moderate PA (min/day)	33.1 ± 13.3	33.5 ± 13.5	32.5 ± 13.3	33.9 ± 13.7	32.2 ± 13.1
Vigorous PA (min/day)	11.8 ± 8.5	13.0 ± 9.2	10.2 ± 7.1	12.1 ± 8.1	11.4 ± 9.0
Moderate-to-vigorous PA (min/day)	45.0 ± 20.1	46.3 ± 21.0	42.7 ± 18.9	46.1 ± 20.6	43.6 ± 19.6
2-year follow-up					
n	88	56	32	47	41
Total PA (counts/min)	334.5 ± 113.5	**354.4 ± 124.3**	**299.7 ± 82.3**	342.8 ± 105.8	325.1 ± 122.3
Moderate PA (min/day)	32.0 ± 10.3	32.6 ± 9.9	30.5 ± 10.9	32.5 ± 9.4	31.1 ± 11.3
Vigorous PA (min/day)	11.7 ± 9.7	**13.4 ± 11.0**	**8.7 ± 5.5**	11.7 ± 8.3	11.8 ± 11.1
Moderate-to-vigorous PA (min/day)	44.0 ± 17.2	46.1 ± 18.5	39.2 ± 13.7	44.2 ± 15.5	43.0 ± 19.1

Values are mean ± SD. Statistically significant values within each group (sex and age groups) are showed in bold ($p<0.05$).

For Peer Review

Table 3. Changes in objectively measured physical activity (PA) of adolescents with Down syndrome in an average week

		Sex		Age group	
	All	Males	Females	Younger	Older
1-year change					
n	92	56	36	48	44
Total PA (counts/min)	-9.0 (-32.6, 14.5)	-17.1 (-52.4, 18.2)	3.5 (-23.2, 30.2)	-7.7 (-38.5, 23.1)	-10.5 (-48.0, 26.9)
Moderate PA (min/day)	-0.5 (-2.6, 1.6)	-0.9 (-3.9, 2.1)	-0.1 (-2.9, 2.9)	0.4 (-2.5, 3.3)	-1.6 (-4.8, 1.6)
Vigorous PA (min/day)	-0.4 (-1.9, 1.1)	-1.3 (-3.6, 0.9)	1.0 (-0.5, 2.5)	0.4 (-1.5, 2.4)	-1.4 (-3.8, 1.1)
Moderate-to-vigorous PA (min/day)	-0.9 (-4.0, 2.1)	-2.2 (-6.7, 2.2)	1.0 (-2.9, 4.8)	0.9 (-3.5, 5.2)	-3.0 (-7.4, 1.4)
2-years change					
n	88	56	47	47	41
Total PA (counts/min)	-21.2 (-44.8, 2.4)	-23.2 (-56.1, 9.6)	-17.6 (-50.1, 14.8)	-21.8 (-55.3, 11.7)	-20.5 (-55.2, 14.2)
Moderate PA (min/day)	-2.2 (-4.6, 0.0)	-2.5 (-5.6, 0.7)	-2.0 (-5.3, 1.2)	-2.3 (-5.5, 0.9)	-2.3 (-5.8, 1.2)
Vigorous PA (min/day)	-0.5 (-2.0, 0.9)	-0.7 (-2.8, 1.4)	-0.3 (-2.3, 1.6)	-0.3 (-2.5, 1.9)	-0.8 (-2.9, 1.3)
Moderate-to-vigorous PA (min/day)	-2.8 (-6.0, 0.4)	-3.1 (-7.7, 1.4)	-2.3 (-6.4, 1.8)	-2.6 (-7.4, 2.1)	-3.1 (-7.5, 1.4)

Values are mean and 95% confidence interval.

For Peer Review

Table 4. Tracking of physical activity (PA) from baseline data to follow-up visits of adolescents with Down syndrome in an average week

		Sex		Age group	
	All	Males	Females	Younger	Older
1-year follow-up					
n	92	56	36	48	44
Total PA (counts/min)	0.638	0.584	0.756	0.640	0.637
Moderate PA (min/day)	0.664	0.591	0.774	0.699	0.631
Vigorous PA (min/day)	0.685	0.670	0.768	0.640	0.736
Moderate-to-vigorous PA (min/day)	0.708	0.664	0.800	0.691	0.746
2-years follow-up					
n	88	56	32	47	41
Total PA (counts/min)	0.638	0.633	0.572	0.556	0.705
Moderate PA (min/day)	0.546	0.453	0.692	0.559	0.537
Vigorous PA (min/day)	0.757	0.773	0.500	0.611	0.847
Moderate-to-vigorous PA (min/day)	0.677	0.646	0.724	0.571	0.765

Values are Pearson's correlation coefficients (r). All values were statistically significant ($p<0.001$).

For Peer Review

Table 5. Changes in objectively measured physical activity (PA) of adolescents with Down syndrome in an average week, by groups of PA at baseline

	Meeting PA guidelines at baseline	
	< 60 min/day	≥ 60 min/day
At baseline		
n	77	22
Total PA (counts/min)	301.4 ± 81.0	544.1 ± 135.3
Moderate PA (min/day)	29.9 ± 8.9	48.0 ± 9.9
Vigorous PA (min/day)	8.5 ± 4.3	25.8 ± 12.3
Moderate-to-vigorous PA (min/day)	38.4 ± 12.3	73.8 ± 14.0
1-year change		
n	72	20
Total PA (counts/min)	9.5 (-12.9, 32.0)	**-75.9 (-145.5, -6.3)**
Moderate PA (min/day)	-0.2 (-2.5, 2.1)	-1.8 (-7.1, 3.6)
Vigorous PA (min/day)	0.8 (-0.4, 2.0)	-4.9 (-10.5, 0.5)
Moderate-to-vigorous PA (min/day)	0.6 (-2.6, 4.0)	-6.8 (-14.9, 1.4)
2-years change		
n	68	20
Total PA (counts/min)	5.0 (-16.8, 26.7)	**-110.2 (-172.4, -48.0)**
Moderate PA (min/day)	-0.7 (-3.1, 1.7)	**-7.7 (-13.1, -2.2)**
Vigorous PA (min/day)	0.5 (-1.1, 2.1)	**-4.1 (-7.7, -0.4)**
Moderate-to-vigorous PA (min/day)	-0.2 (-3.5, 3.1)	**-11.7 (-19.9, -3.6)**

Values are mean ± SD at baseline and mean and 95% confidence interval at 1-and-2-year change. Statistically significant values within each group are showed in bold (p<0.05).

For Peer Review

Table 1 (supplementary table). Objectively measured physical activity (PA) of adolescents with Down syndrome in each follow-up visit in weekdays

		Sex		Age group	
	All	Males	Females	Younger	Older
Baseline					
n	99	61	38	53	46
Total PA (counts/min)	357.1 ± 133.6	368.8 ± 141.9	338.4 ± 118.2	373.4 ± 126.7	338.4 ± 140.1
Moderate PA (min/day)	35.4 ± 12.5	35.4 ± 12.5	35.3 ± 12.7	35.9 ± 12.8	34.8 ± 12.2
Vigorous PA (min/day)	12.7 ± 9.3	**14.2 ± 10.6**	**10.3 ± 6.1**	12.8 ± 7.8	12.5 ± 10.8
Moderate-to-vigorous PA (min/day)	48.1 ± 19.8	49.6 ± 20.9	45.6 ± 17.7	48.7 ± 18.9	47.3 ± 20.9
1-year follow-up					
n	92	56	36	48	44
Total PA (counts/min)	353.9 ± 136.0	360.4 ± 142.7	344.0 ± 126.2	364.4 ± 132.6	342.6 ± 140.4
Moderate PA (min/day)	35.2 ± 14.2	34.7 ± 13.8	35.8 ± 14.8	36.1 ± 14.4	34.1 ± 14.1
Vigorous PA (min/day)	12.9 ± 9.5	13.7 ± 9.6	11.8 ± 9.2	13.1 ± 8.7	12.9 ± 10.4
Moderate-to-vigorous PA (min/day)	48.1 ± 21.8	48.4 ± 21.8	47.6 ± 22.0	49.2 ± 21.7	47.0 ± 22.1
2-years follow-up					
n	88	57	31	47	41
Total PA (counts/min)	340.3 ± 126.5	349.3 ± 131.0	323.8 ± 118.1	345.6 ± 120.7	334.3 ± 134.2
Moderate PA (min/day)	33.4 ± 11.3	33.7 ± 10.6	32.8 ± 12.7	33.4 ± 10.1	33.5 ± 12.7
Vigorous PA (min/day)	12.4 ± 10.7	13.3 ± 11.5	10.9 ± 8.8	12.1 ± 8.7	12.4 ± 12.6
Moderate-to-vigorous PA (min/day)	45.8 ± 18.8	47.0 ± 19.6	43.7 ± 17.4	45.4 ± 14.4	46.4 ± 21.5

Values are mean and 95% confidence interval. Statistically significant values between each group (sex and age groups) are showed in bold ($p<0.05$).

For Peer Review

Table 2 (supplementary table). Objectively measured physical activity (PA) of adolescents with Down syndrome in each follow-up visit in weekends days

		Sex		Age group	
	All	Males	Females	Younger	Older
Baseline					
n	90	56	34	48	42
Total PA (counts/min)	343.8 ± 203.5	**393.7 ± 234.6**	**261.6 ± 93.2**	330.6 ± 169.5	358.9 ± 237.7
Moderate PA (min/day)	28.9 ± 15.0	**32.2 ± 15.4**	**23.5 ± 12.8**	28.7 ± 14.9	29.1 ± 15.3
Vigorous PA (min/day)	11.0 ± 13.8	**14.0 ± 16.5**	**6.1 ± 4.5**	9.2 ± 9.6	13.0 ± 17.2
Moderate-to-vigorous PA (min/day)	39.9 ± 24.2	**46.2 ± 26.3**	**29.6 ± 16.2**	37.9 ± 21.6	42.1 ± 27.1
1-year follow-up					
n	86	51	35	44	42
Total PA (counts/min)	318.2 ± 183.5	345.8 ± 207.5	278.1 ± 134.3	306.6 ± 162.5	330.4 ± 204.4
Moderate PA (min/day)	28.2 ± 18.0	30.5 ± 19.5	24.9 ± 15.3	27.6 ± 18.3	29.0 ± 18.0
Vigorous PA (min/day)	8.9 ± 9.8	10.6 ± 11.3	6.4 ± 6.5	9.1 ± 9.6	8.7 ± 10.1
Moderate-to-vigorous PA (min/day)	37.2 ± 25.0	41.1 ± 27.1	31.5 ± 20.8	36.7 ± 26.2	37.7 ± 24.2
2-years follow-up					
n	77	50	27	41	36
Total PA (counts/min)	327.1 ± 140.7	351.6 ± 146.1	281.6 ± 119.9	350.9 ± 158.2	300.0 ± 114.1
Moderate PA (min/day)	28.6 ± 13.9	30.3 ± 14.6	25.5 ± 12.1	31.0 ± 14.2	26.0 ± 13.4
Vigorous PA (min/day)	10.2 ± 11.9	**12.4 ± 14.0**	**6.6 ± 5.2**	11.7 ± 14.1	8.7 ± 8.9
Moderate-to-vigorous PA (min/day)	39.0 ± 21.9	**42.7 ± 24.0**	**32.1 ± 15.6**	42.8 ± 24.2	34.7 ± 18.4

Values are mean and 95% confidence interval. Statistically significant values between each group (sex and age groups) are showed in bold (p<0.05).

For Peer Review

Table 3 (supplementary table). Changes in objectively measured physical activity (PA) of adolescents with Down syndrome in weekdays

		Sex		Age group	
	All	Males	Females	Younger	Older
1-year change					
n	92	56	36	48	44
Total PA (counts/min)	0.1 (-21.8, 22.2)	-8.8 (-40.4, 22.9)	14.1 (-14.1, 42.2)	0.3 (-30.7, 31.4)	-0.5 (-32.4, 32.3)
Moderate PA (min/day)	0.2 (-1.9, 2.3)	-0.5 (-3.5, 2.4)	1.3 (-1.9, 4.6)	1.4 (-1.6, 4.4)	-1.2 (-4.4, 2.1)
Vigorous PA (min/day)	0.4 (-1.0, 1.9)	-0.6 (-2.7, 1.5)	2.1 (-0.2, 4.3)	0.8 (-1.3, 3.0)	0.1 (-2.2, 2.3)
Moderate-to-vigorous PA (min/day)	0.6 (-2.6, 3.8)	-1.1 (-5.6, 3.3)	3.4 (-1.2, 8.1)	2.2 (-2.4, 6.9)	-1.1(-5.6, 3.5)
2-years change					
n	88	57	31	47	41
Total PA (counts/min)	-15.9 (-42.6, 10.7)	-24.3 (-58.1, 9.4)	-0.5 (-45.5, 44.8)	-23.3 (-60.3, 13.7)	-7.5 (-47.6, 32.5)
Moderate PA (min/day)	-1.9 (-4.4, 0.4)	-2.1 (-5.3, 1.2)	-1.7 (-5.1, 1.6)	-2.5 (-5.8, 0.7)	-1.3 (-5.0, 2.4)
Vigorous PA (min/day)	-0.2 (-2.1, 1.8)	-0.9 (-3.4, 1.6)	1.2 (-2.1, 4.5)	-0.6 (-3.4, 2.2)	0.3 (-2.6, 3.3)
Moderate-to-vigorous PA (min/day)	-2.1 (-5.7, 1.4)	-2.9 (-7.8, 1.8)	-0.5 (-5.8, 4.8)	-3.1 (-8.3, 2.0)	-1.0 (-6.1, 4.2)

Values are mean and 95% confidence interval.

For Peer Review

Table 4 (supplementary table). Changes in objectively measured physical activity (PA) of adolescents with Down syndrome in weekends days

		Sex		Age group	
	All	Males	Females	Younger	Older
1-year change					
n	79	48	31	40	39
Total PA (counts/min)	-23.5 (-69.5, 22.5)	-45.8 (-113.7, 22.1)	11.0 (-43.6, 65.6)	-12.6 (-66.4, 41.1)	-34.7 (-112.3, 43.1)
Moderate PA (min/day)	-0.3 (-4.4, 3.8)	-0.9 (-6.7, 4.8)	0.7 (-5.3, 6.7)	0.2 (-5.8, 5.8)	-0.6 (-6.9, 5.6)
Vigorous PA (min/day)	-2.5 (-5.2, 0.2)	-4.1 (-8.3, 0.1)	0.1 (-2.4, 2.5)	-0.7 (-2.3, 2.1)	-5.0 (-10.0, 0.1)
Moderate-to-vigorous PA (min/day)	-2.7 (-8.0, 2.4)	-5.0 (-12.1, 1.9)	0.7 (-7.3, 8.8)	-0.4 (-7.5, 7.4)	-5.6 (-13.1, 1.9)
2-years change					
n	73	48	25	39	34
Total PA (counts/min)	-11.1 (-53.1, 30.8)	-22.8 (-80.3, 34.7)	11.3 (-46.1, 68.8)	14.6 (-39.3, 68.6)	-40.6 (-107.8, 26.5)
Moderate PA (min/day)	-0.1 (-4.1, 3.9)	-1.3 (-6.8, 4.0)	2.3 (-3.7, 8.5)	1.9 (-3.6, 7.5)	-2.4 (-8.6, 3.9)
Vigorous PA (min/day)	-0.1 (-2.5, 2.4)	-0.2 (-3.8, 3.4)	0.2 (-2.3, 2.7)	2.5 (-0.5, 5.4)	-3.0 (-7.1, 1.0)
Moderate-to-vigorous PA (min/day)	-0.2 (-5.8, 5.5)	-1.6 (-9.3, 6.2)	2.5 (-5.2, 10.4)	4.4 (-3.4, 12.3)	-5.4 (-13.7, 2.9)

Values are mean and 95% confidence interval.

For Peer Review