*African Journal for Physical, Health Education, Recreation and Dance (AJPHERD)* Volume 20(2:2), June 2014, pp. 765-779.

# Comparative study of physical activity patterns among school children in Kenya and Canada: Results from the ISCOLE Project

STELLA K. MUTHURI, [1,2], LUCY-JOY M. WACHIRA[3], VINCENT O. ONYWERA AND MARK S. TREMBLAY[1,2,3]

[1]*Children's Hospital of Eastern Ontario Research Institute, 401 Smyth Road, Ottawa, Ontario, Canada, K1H 8L1. E-mail: smuthuri@hotmail.com*
[2]*University of Ottawa, 75 Laurier Avenue East, Ottawa, Ontario, Canada, K1N 6N5.*
[3]*Kenyatta University, P.O. Box 43844 – 00100, Nairobi, Kenya.*

*(Received: 23 January 2014 ; Revision Accepted: 24 May 2014 )*

**Abstract**

Examination of the timing and patterns of daily activity are crucial in understanding when children accumulate the highest levels of physical activity. The objectives of this study were to examine moderate-to-vigorous physical activity (MVPA) patterns accrued by time of day among Kenyan children, and compare activity patterns in Kenya to those of Canadian children. Physical activity and body weights of participating children were measured by accelerometry and anthropometry, while supplementary self-report data were captured by questionnaires. Data were collected as part of a larger International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE) in Nairobi for ISCOLE-Kenya and in the Ottawa Region for ISCOLE-Canada. A total of 555 Kenyan and 541 Canadian children 9 to 11 years were included in the analyses. In Kenya, boys, under/healthy weight, and children attending public (lower socioeconomic status (SES)) schools were found to have significantly higher MVPA levels compared to girls, overweight/obese, and children attending private (higher SES) schools respectively. MVPA on weekdays was higher than on weekend-days. Activity profiles among Kenyan and Canadian children were very similar; however, Kenyan children had significantly higher MVPA and lower sedentary time on weekend-days. MVPA patterns among urban Kenyan children were largely similar to those of urban Canadian children when assessed by sex, BMI category, and weekday/weekend days. However, in the Kenyan sample, unlike in many higher income countries, lower SES was associated with higher MVPA.

**Keywords:** Accelerometry, physical activity patterns, school children, Kenya, Canada.

***How to cite this article:***
Muthuri, S.K., Wachira, L-J.M., Onywera, V.O. & Tremblay, M.S. (2014). Comparative study of physical activity patterns among school children in Kenya and Canada: Results from the ISCOLE Project. *African Journal for Physical, Health Education, Recreation and Dance,* 20(2:2), 765-779.

## Introduction

Physical activity guidelines developed by the World Health Organization (WHO) recommend that children and youth (5 – 17 years) should accumulate at least 60 minutes of daily moderate-to-vigorous physical activity (MVPA) for positive health outcomes (WHO, 2010). Canadian sedentary behaviour guidelines further

recommend that children of this age group should limit their recreational sedentary screen time to no more than 2 hours per day (Canadian Society for Exercise Physiology, 2011), since sedentary behaviours are independently associated with adverse health outcomes (Tremblay, Colley, Saunders, Healy, & Owen, 2010). Investigation of the timing and patterns of daily physical activity, including MVPA, light physical activity, and sedentary time, are crucial in understanding how, when, or where children accumulate the highest levels of physical activity (Cairney, Veldhuizen, Kwan, Hay & Faught, 2014; Colley et al., 2011; Garriguet & Colley, 2012; Laguna et al., 2013; Ramirez-Rico, Hilland, Foweather, Fernández-Garcia & Fairclough, 2014; Sigmund, Sigmundová, Snoblová & Gecková, 2014), thereby providing the evidence for informed interventions and strategies to promote physical activity and prevent sedentary behaviours in this population.

Objectively measured physical activity in Canada showed that only 7% of children and youth accumulated the recommended ≥ 60 minutes of daily MVPA, with those that were overweight/obese accumulating even less (Colley et al., 2011). A higher proportion of boys (9%) than girls (4%) met these recommendations (Colley et al., 2011). This study also revealed that children were spending an average of two thirds of their waking hours - 8.6 hours - in sedentary activities daily (Colley et al., 2011). Garriguet and Colley (2012) found that among Canadian children and youth (6 -19 years), boys on average accumulated more MVPA than girls, and that children and youth spent more time in MVPA on weekdays than on weekend-days. Similar findings of lower MVPA among girls, among overweight/obese children, and on weekend-days compared to weekdays have been reported in other higher income countries (Cairney et al., 2014; Ekelund et al., 2002; Laguna et al., 2013; Mota, Santos, Guerra, Ribeiro & Duarte, 2003; Nilsson et al., 2009; Page et al., 2005; Ramirez-Rico et al., 2014; Sigmund et al., 2014). Further, various studies have shown that lower socioeconomic status (SES) is associated with lower levels of physical activity, more time spent in sedentary behaviours, and higher risk for unhealthy lifestyles compared to higher SES children (Drenowatz et al., 2010; Jimenez Pavon et al., 2010).

Given that much of the knowledge available on these emerging patterns of physical activity is informed by studies conducted in higher income countries (Haug et al., 2009; Janssen et al., 2005; Katzmarzyk et al., 2013), it is important that we examine whether these findings and relationships are maintained across other regions of the world, including lower income countries such as Kenya. While there is lack of nationally representative data on physical activity and sedentary behaviour in Kenya, data from a recent study (International Study of Childhood Obesity, Lifestyle and Environment, ISCOLE-Kenya) revealed that mean daily sedentary time in a sample of urban living children from Nairobi was 6.6 hours (Muthuri, Wachira, Onywera & Tremblay, 2014a). Mean daily time

spent in MVPA was 36 minutes, with only 12.6% of participating children meeting the WHO recommendation of ≥ 60 minutes of daily MVPA (Muthuri et al., 2014a).

The primary objective of this study was to examine the levels of MVPA accrued by time of day among Kenyan children, by sex, BMI (WHO) category, type of school (an indicator of SES), and on weekdays compared to weekend-days. The secondary objective of this study was to compare activity patterns in the Kenyan setting, to activity patterns in the Canadian setting, in order to gain insight into the similarities or differences in accumulation of moderate-to-vigorous, light physical activity, and sedentary time among school-aged children, by time of day and on weekdays/weekend-days.

## Methodology

Physical activity and body weight measurements of the participating children were obtained by accelerometry and anthropometric assessment. Supplementary self-report information was captured by the use of questionnaires related to lifestyle and the environment. Data collection was conducted as part of the ISCOLE project (Katzmarzyk et al., 2013).

### *The ISCOLE Project*

The primary aim of the ISCOLE project was to investigate the influence of behavioural settings and the physical, social, and policy environments on the observed relationship between lifestyle characteristics and weight status in approximately 500 children from each of 12 countries from the major regions of the world (Katzmarzyk et al., 2013). Data collection was conducted in the urban city of Nairobi, for ISCOLE-Kenya's assessments, and in the Ottawa Region for the ISCOLE-Canada's assessments, following ethical approval from the local coordinating centers – Kenyatta University in Nairobi, and the Children's Hospital of Eastern Ontario in Ottawa. Extensive details of the ISCOLE study protocol are provided elsewhere (Katzmarzyk et al., 2013), and a brief overview provided here.

### *Study design and population*

A sex-balanced sample of approximately 500 children between the ages of 9 and 11 years was recruited for each of the sites (Nairobi and Ottawa). In Nairobi, the primary sampling frame was a convenience sample of non-boarding public and private schools, whereby type of school, public verses private, was an indicator of lower and higher SES respectively. The secondary sampling frame was classrooms in the recruited schools that best yielded a final sample with minimal variability around 10 years of age. In the Ottawa Region, schools were stratified

into four groups with proportional representation (English Public, French Public, English Catholic, and French Catholic). At both sites, schools within each stratum (type of school) were invited to participate (proportional to attendance by school children), and thereafter parental consent and child assent sought prior to inclusion in the study. Further details on the sampling strategy are provided elsewhere (Katzmarzyk et al., 2013).

*Questionnaires*

A diet and lifestyle questionnaire was completed by participating children and captured information about their individual level factors including sex, while a school environment questionnaire completed by a school administrator captured information on school characteristics such as the type of school. Full details of the questionnaires are provided elsewhere (Katzmarzyk et al., 2013).

*Anthropometry*

Trained research staff measured standing height of participating children using the Seca 213 portable stadiometer (Birmingham, United Kingdom), with the participant as erect as possible and head positioned in the Frankfort horizontal plane (Katzmarzyk et al., 2013). The weight of each participant was measured using a portable Tanita Body Composition Analyser (SC-240, Illinois, USA), after all outer clothing, heavy pocket items, shoes, and socks were removed (Katzmarzyk et al., 2013). Body mass index (BMI) was derived from weight and height ($kg/m^2$), and BMI z-scores calculated based on growth reference algorithms developed by the WHO for children and youth (de Onis et al., 2007). Children were thereafter grouped into underweight/healthy weight and overweight/obese categories.

*Accelerometry*

Direct monitoring of physical activity and sedentary time was achieved by use of ActiGraph GT3X+ accelerometers at a one second epoch setting. Accelerometers were firmly attached to belts and distributed to the children who were instructed on appropriate wearing of the instruments; on the right side of their waists at all times except when bathing or swimming (including when sleeping). Participants were required to wear the devices for at least 7 consecutive days, plus an initial familiarisation day, in order to maximise the number of children providing a minimum of 4 days of wear of at least 10 hours per day, with at least one valid weekend-day (Katzmarzyk et al., 2013). Non-wear time within a day was considered 60 consecutive minutes of ‘0’ counts. Reminder telephone calls and reminders from class teachers were helpful in ensuring compliance with the protocol. Accelerometry data were downloaded, the logs reviewed for completeness, and data reduction completed using cut-points developed by

Treuth et al., which are validated in children and youth (Treuth et al., 2004). Time spent in sedentary, light and MVPA were then determined.

*Statistical analysis*

All statistical analyses presented in this study were computed using SAS version 9.3 (SAS Institute, Cary, North Carolina, USA). Minute-by-minute data downloaded from the accelerometers were summarized into one record per person, thereby allowing for the extraction of mean minute and hourly level sample data. Significant differences in the distribution of two sets of data of moderate-to-vigorous, light physical activity, and sedentary time, were investigated using the two-sample Kolmogorov-Smirnov test, a non-parametric test that compares the empirical distribution functions (EDFs) of two data sets (Kirkman, 1996). The Kolmogorov-Smirnov test is one of the more useful and general methods for comparing the distribution between two samples; and it makes no assumption about the distribution of data (Kirkman, 1996). It was selected for use in these analyses due to its sensitivity to differences in location and shape of cumulative distribution functions, and because it is fairly robust to outliers. With a null hypothesis that both data sets are from populations with identical distributions, this test searches for any violation of that null hypothesis, that is, different medians, variances, or distributions (Kirkman, 1996). The Kolmogorov-Smirnov test seeks to determine how far apart the relative frequency distributions of the two data sets are – at the point where they are furthest apart – that is, it computes the maximum vertical deviation (supremum) between the two cumulative distributions, and then calculates a p-value based on this difference, while accounting for the sample sizes of the data sets (Kirkman, 1996).

## Results

Participating children were 9.0 to 11.9 years of age at the time of recruitment. A total of 555 Kenyan participants (46.4% boys, 53.6% girls) recruited from 29 schools in Nairobi, completed the required anthropometric assessments and had valid accelerometry wear data.

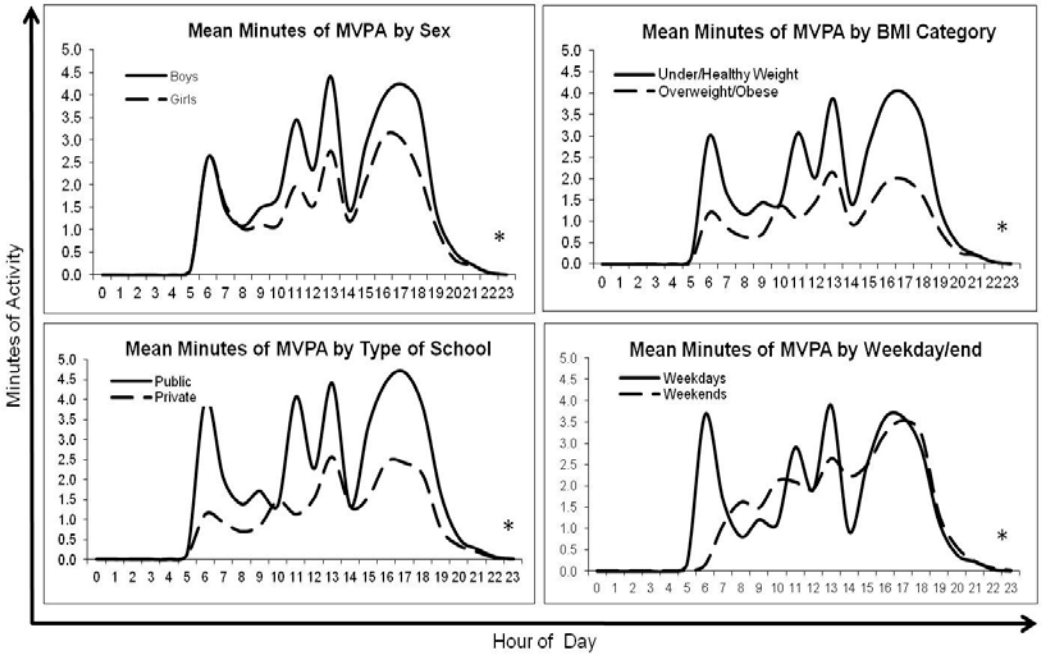


**Figure 1:** Mean daily minutes of moderate-to-vigorous physical activity patterns by time of day among Kenyan children

*Significant difference in the levels of moderate-to-vigorous physical activity by sex [p<0.0001], by BMI (WHO) category [p<0.0001], by type of school [p<0.0001], and by weekdays/weekend-days [p<0.0001].

Of these, 79.8% were underweight/healthy weight while 20.2% were overweight/obese, and 52.2% were attending public schools while 47.8% were attending private schools in Nairobi. An age matched sample of 541 children (41.9% boys, 58.1% girls) was recruited from 26 schools in the Ottawa Region of Canada. Of these, 69.2% were underweight/healthy weight while 30.8% were overweight/obese.

*Activity patterns among Kenyan children*

The MVPA patterns among Kenyan children are presented in Figure 1. Boys, under/healthy weight children, and public school attending children were found to have significantly higher mean daily MVPA levels, compared to girls, overweight/obese children and private school attending children respectively (p<0.0001). MVPA distinctly peaked at around 6:30 am and 11:30 am in the morning, 1:30 pm in the afternoon, and 5:30 pm in the evening.

Mean daily MVPA levels on weekdays was significantly higher than on weekend-days (p<0.0001). On weekdays, MVPA levels were highest between 6:00 – 7:00 am, 11:00 – 12:00 noon, 1:00 – 2:00 pm, and 4:00 – 6:00 pm. On

weekend-days, MVPA levels gradually increased throughout the day starting at 9:00 am, and were highest between 4:30 – 6:30 pm.

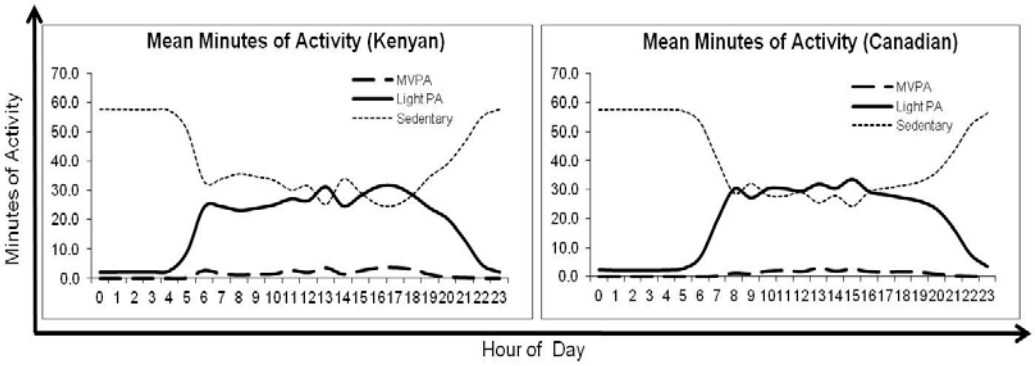


**Figure 2:** Mean daily minutes of moderate-to-vigorous, light physical activity, and sedentary time among Kenyan and Canadian children.

*Activity pattern comparisons between Kenyan and Canadian children*

As shown in Figure 2, an examination of the activity profiles among Kenyan and Canadian children revealed considerable similarities in the trends. Comparative analysis of mean daily minutes of MVPA, light physical activity, and sedentary time between Kenyan and Canadian children revealed no significant differences at the different intensity levels, as represented in Figure 3. There were no significant differences found even when boys and girls were assessed separately; however, there was a trend towards higher mean MVPA levels in Kenyan verses Canadian children, particularly when boys and girls were assessed separately. More generally, most MVPA was found to occur between 5:30 am and 8:30 pm for Kenyan children and between 7:30 am and 9:30 pm for Canadian children.

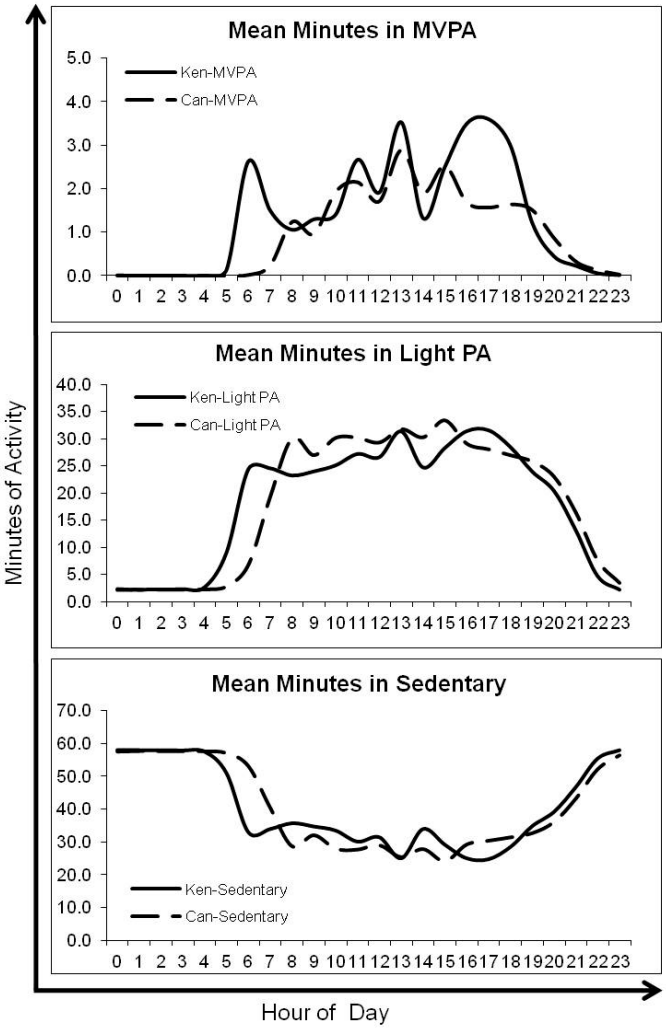


**Figure 3:** Kenyan-Canadian comparison of mean daily minutes of moderate-to-vigorous, light physical activity, and sedentary time

(No significant difference in the levels of moderate-to-vigorous, light physical activity, and sedentary time between Kenyan and Canadian children).

As shown in Figure 4, comparative analysis of mean daily minutes of MVPA, light physical activity, and sedentary time on weekdays and weekend-days revealed that there was a significant difference between Kenyan and Canadian children in their accumulation of MVPA and sedentary time on weekend-days ($p<0.0001$). However, there were no significant differences in the levels of light physical activity on weekend-days, or in the levels of MVPA, light physical activity, and sedentary time on weekdays.

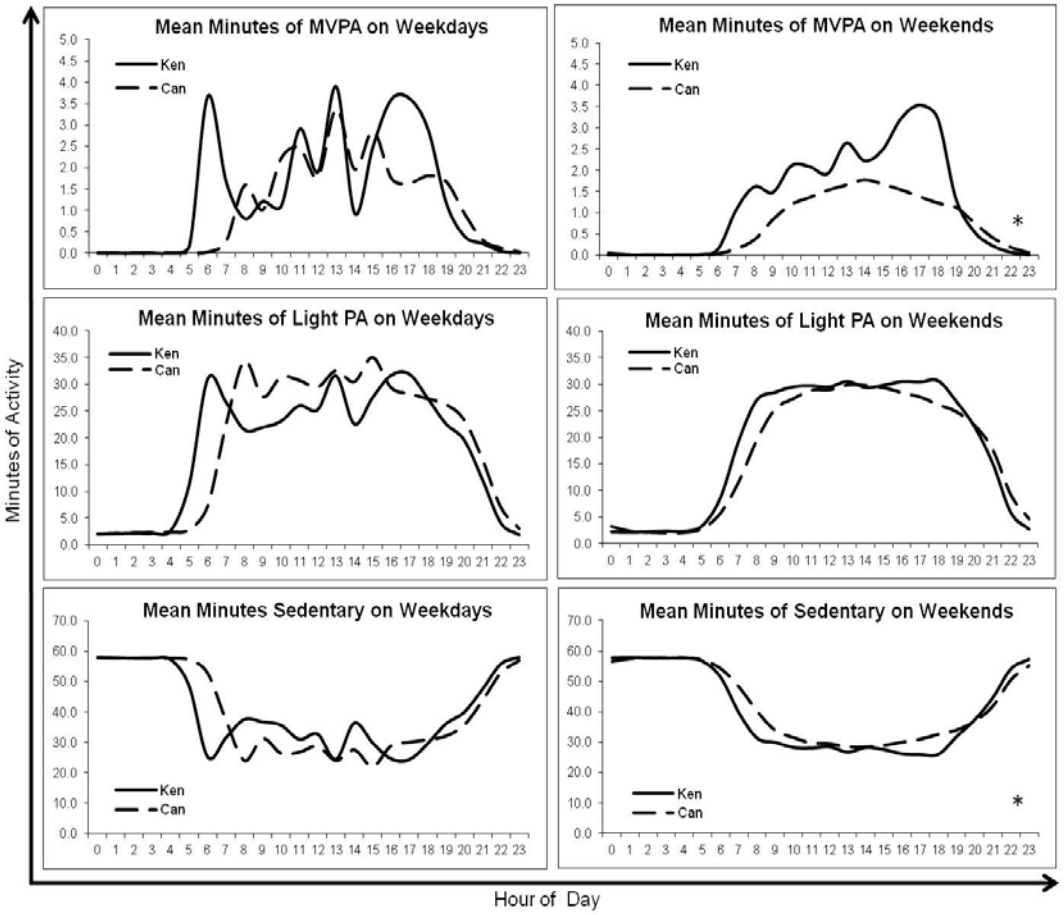


**Figure 4:** Kenyan-Canadian comparison of mean daily minutes of moderate-to-vigorous, light physical activity, and sedentary time on weekdays and weekend-days.

*Significant difference in the levels of moderate-to-vigorous physical activity [p=0.019] and sedentary time [p=0.043] between Kenyan and Canadian children on weekend-days. No significant difference in the levels of light physical activity on weekend-days, or in either activity level on weekdays.

## Discussion

### *Activity patterns among Kenyan children*

Kenyan boys were found to have higher mean daily MVPA levels throughout the day compared to girls. This sex difference in the accumulation of physical activity has also been observed in various other low and high income countries (Cairney et al., 2014; Colley et al., 2011; Garriguet & Colley, 2012; Mota et al., 2003; Muthuri et al., 2014b; Page et al., 2005; Sigmund et al., 2014). Differences in gender roles (e.g. participation in different tasks or chores) and a higher motivation inherent in boys to participate in physical activity may explain this sex difference.

Overweight/obese children in this setting were also found to engage in lower levels of MVPA than their peers. Similarly, overweight/obese children in other global regions and settings have been found to be generally less physically active than their non-overweight/obese counterparts, particularly in girls (Colley et al., 2011; Laguna et al., 2013; Page et al., 2005; Sigmund et al., 2014). It has been suggested that this difference in physical activity may not be necessarily equal to a difference in energy expenditure (Ekelund et al., 2002), but that lower physical activity may be related to engagement in other behaviours such as consumption of energy dense foods, sedentary behaviours, and other activities undertaken by overweight/obese children (Page et al., 2005).

The study also revealed that public school attending (lower SES) children were found to have significantly higher mean daily MVPA levels compared to private school attending (higher SES) children. This inverse relationship between SES and physical activity is the opposite of findings reported in many higher income countries (Drenowatz et al., 2010; Jimenez Pavon et al., 2010); however, these findings are commensurate with studies conducted in Kenya showing similar associations between higher SES and urbanization, with decreased time spent in physical activity (Larsen, Christensen, Nolan & Sondergaard, 2004; Ojiambo et al., 2012; Onywera et al., 2012).

Time spent in MVPA in this sample of children was higher on weekdays than on weekend-days, much like reports from various studies conducted in higher income countries (Garriguet & Colley, 2012; Laguna et al., 2013; Nilsson et al., 2009; Ramirez-Rico et al., 2014). Further, similar to findings in the USA and Canada, the period before-school, the mid-morning break, lunch-time, and the period after school, were all consistent with the distinctly higher levels of MVPA observed on weekdays (Garriguet & Colley, 2012; Tudor-Locke, Lee, Morgan, Beighle & Pangrazi, 2006). These are all times when children are released from their classrooms. On weekend-days, there was a gradual increase in MVPA levels observed throughout the day, culminating in the highest levels right before dinner-time. Overall, weekday physical activity may represent the most important source of MVPA; however, weekend-days represent an important point of intervention for promoting physical activity in this age of children, and a possible means of establishing self-directed healthy active living habits.

*Activity pattern comparisons between Kenyan and Canadian children*

Activity profiles among Kenyan and Canadian children were very similar, with no significant differences observed in levels of MVPA, light physical activity, and sedentary time accrued by time of day. These similarities may indeed be reflective of a deeper concern, since lower income countries like Kenya may be adopting behavioural patterns that could lead to a growing problem of physical inactivity, comparable to observations in higher income countries. More broadly,

while the health benefits of maintaining healthy active lifestyles are well known, in many Sub-Saharan African countries, declines in habitual physical activity (e.g. manual labour and the practice of walking long distances) and increases in sedentary behaviour (e.g. desk work and motorised transport) have been reported (Onywera, 2010; Steyn & Damasceno, 2006; Unwin et al., 2001). In Kenya specifically, a number of studies have shown emerging evidence of a physical inactivity problem in school-aged children in Kenya, particularly urban living children, in contrast to their rural living peers (Croteau, Schofield, Towle, & Suresh, 2011; Larsen et al., 2004; Ojiambo et al., 2012, Onywera et al., 2012).

Kenyan children were found to start their day earlier (5:30 am verses 7:30 am), and end their day earlier (8:30 pm verses 9:30 pm), compared to Canadian children. This may be indicative that Kenyan children were awake for approximately an hour longer than their Canadian peers, or that the Canadian children were much more sedentary in the early morning, and requires further exploration. An examination of the ISCOLE-Kenya school start times revealed that sampled schools in Nairobi started their day between 6:30 am and 8:20 am, and had school end times that fell between 2:45 pm and 5:00 pm, while ISCOLE-Canada school start times ranged from 7:55 am to 9:15 am, and end times ranged from 2:25 pm to 3:45 pm. These differences in school start and end time ranges may explain why Kenyan children were found to seemingly start their day earlier and have more minutes of movement during the day compared to their Canadian peers.

Comparative analysis revealed that Kenyan children had higher MVPA levels and lower sedentary time than their Canadian counterparts on weekend-days. This may indeed account for the seeming – but non-significant - trend towards higher overall MVPA levels in Kenyan verses Canadian children, particularly when boys and girls were assessed separately. Children in the Kenyan setting may be spending less time in sedentary pursuits than their Canadian peers on weekend-days, as a consequence of reduced penetration of screen-based options for children and youth, even in the urban city of Nairobi. These children may therefore be engaging in more active play or other activities that account for higher MVPA levels on weekend-days compared to Canadian children.

While this study is limited by its cross-sectional design and by not being nationally representative, its strength lies in the standardized, objective measures collected. Further, the findings clearly reveal differences and similarities in the accumulation of MVPA, light physical activity, and sedentary time, between Kenyan and Canadian children.

## Conclusions

In the Kenyan sample, girls, overweight/obese, and private school attending (higher SES) children had significantly lower mean daily MVPA levels compared to boys, under/healthy weight, and public school attending (lower SES) children. MVPA on weekdays was significantly higher than on weekend-days. These results are similar to patterns observed in Canada and other higher income countries. However, the inverse relationship between SES and MVPA in the Kenyan sample is unlike that observed in many higher income countries. Activity profiles among Kenyan and Canadian children were very similar; however, there were significant differences between Kenyan and Canadian children in their accumulation of MVPA and sedentary time on weekend-days. Generally, the findings of this study will serve to further promote collaboration in surveillance and dissemination efforts among researchers as they attempt to address the potential population health concerns caused by childhood physical inactivity, by highlighting similarities and differences in activity patterns among school children from different global regions.

## Acknowledgements

The authors are grateful to all participants of the ISCOLE-Kenya and ISCOLE-Canada studies, and the research assistants who helped with data collection. We thank biostatistician Kathryn Williams for her guidance with statistical analysis for this manuscript. In addition, we would like to thank the ISCOLE Coordinating Center staff at the Pennington Biomedical Research Center for study coordination and data management (Peter T. Katzmarzyk and Timothy S. Church, principal investigators, and Denise Lambert, project manager).

## References

Cairney, J., Veldhuizen, S., Kwan, M., Hay, J. & Faught, B.E. (2014). Biological age and sex-related declines in physical activity during adolescence. *Medicine and Science in Sports and Exercise*, 46(4), 730-735.

Canadian Society for Exercise Physiology (2011). Canadian physical activity guidelines. www.csep.ca/guidelines/

Colley, R.C., Garriguet, D., Janssen, I., Craig, C.L., Clarke, J. & Tremblay, M.S. (2011). Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports*, 22(1), 15-23.

Croteau, K., Schofield, G., Towle, G. & Suresh, V. (2011). Pedometer-determined physical activity of western Kenyan children. *Journal of Physical Activity and Health*, 8(6), 824-828.

de Onis, M., Onyango, A.W., Borghi, E., Siyam, A., Nishida, C. & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization*, 85(9), 660-667.

Drenowatz, C., Eisenmann, J.C., Pfeiffer, K.A., Welk, G., Heelan, K., Gentile, D. & Walsh, D. (2010). Influence of socio-economic status on habitual physical activity and sedentary behavior in 8- to 11-year old children. *BMC Public Health*, 10, 214.

Ekelund, U., Aman, J., Yngve, A., Renman, C., Westerterp, K. & Sjostrom, M. (2002). Physical activity but not energy expenditure is reduced in obese adolescents: a case-control study. *American Journal of Clinical Nutrition*, 76(5), 935−941.

Garriguet, D. & Colley, R.C. (2012). Daily patterns of physical activity among Canadians. *Health Reports*, 23(2), 27-32.

Haug, E., Rasmussen, M., Samdal, O., Iannotti, R., Kelly, C., Borraccino, A. Vereecken, C., Melkevik, O., Lazzeri, G., Giacchi, M., Ercan, O., Due, P., Ravens-Sieberer, U., Currie, C., Morgan, A. & Ahluwalia, N. (2009). Overweight in school-aged children and its relationship with demographic and lifestyle factors: Results from the WHO-collaborative health behaviour in school-aged children (HBSC) study. *International Journal of Public Health*, 54(Suppl. 2), 167–179.

Janssen, I., Katzmarzyk, P.T., Boyce, W.F., Vereecken, C., Mulvihill, C., Roberts, C., Currie, C. & Pickett, W. (2005). Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. *Obesity Reviews*, 6(2), 123–132.

Jimenez Pavon, D., Ortega, F.P., Ruiz, J.R., Espana Romero, V., Garcia Artero, E., Moliner Urdiales, D., Gomez Martinez, S., Vicente Rodriguez, G., Manios, Y., Beghin, L., Repasy, J., Sjostrom, M., Moreno, L.A., Gonzalez Gross, M. & Castillo, M.J. (2010). Socioeconomic status influences physical fitness in European adolescents independently of body fat and physical activity: The HELENA study. *Nutricion Hospitalaria*, 25(2), 311-316.

Katzmarzyk, P.T., Barreira, T.V., Broyles, S.T., Champagne, C.M., Chaput, J.P., Fogelholm, M., Hu, G., Johnson, W.D., Kuriyan, R., Kurpad, A., Lambert, E.V., Maher, C., Maia, J., Matsudo, V., Olds, T., Onywera, V., Sarmiento, O.L., Standage, M., Tremblay, M.S., Tudor-Locke, C., Zhao, P. & Church, T.S. (2013). The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE): Design and methods. *BMC Public Health*, 13, 900.

Kirkman, T.W. (1996). Statistics to use: Kolmogorov-Smirnov test. http://www.physics. csbsju. edu/stats/KS-test.html

Laguna, M., Ruiz, J.R., Gallardo, C., Garcia-Pastor, T., Lara, M.T. & Aznar, S. (2013). Obesity and physical activity patterns in children and adolescents. *Journal of Paediatrics and Child Health*, 49(11), 942-949.

Larsen, H.B., Christensen, D.L., Nolan, T. & Sondergaard, H. (2004). Body dimensions, exercise capacity and physical activity level of adolescent Nandi boys in western Kenya. *Annals of Human Biology*, 31(2), 159-173.

Mota, J., Santos, P., Guerra, S., Ribeiro, J.C. & Duarte, J.A. (2003). Patterns of daily physical activity during school days in children and adolescents. *American Journal of Human Biology*, 15(4), 547-553.

Muthuri, S.K., Wachira, L.M., Onywera, V.O. & Tremblay, M.S. (2014a). Correlates of objectively measured overweight/obesity and physical activity in Kenyan school children: results from ISCOLE-Kenya. *BMC Public Health*, 14, 436 doi:10.1186/1471-2458-14-436.

Muthuri, S.K., Wachira, L.M, Leblanc, A.G., Francis, C.E., Sampson, M., Onywera, V.O., Tremblay, M.S. (2014b). Temporal trends and correlates of physical activity, sedentary behaviour, and physical fitness among school-aged children in Sub-Saharan Africa: a systematic review. *International Journal of Environment Research and Public Health*,11, 3327-3359.

Nilsson, A., Anderssen, S.A., Andersen, L.B., Froberg, K., Riddoch, C., Sardinha, L.B. & Ekelund, U. (2009). Between- and within-day variability in physical activity and inactivity in 9- and 15-year-old European children. Scandinavian Journal of Medicine and Science in Sports, 19(1), 10-18.

Ojiambo, R.M., Easton, C., Casajus, J.A., Konstabel, K., Reilly, J.J. & Pitsiladis, Y. (2012). Effect of urbanisation on objectively measured physical activity levels, sedentary time, and indices of adiposity in Kenyan adolescents. *Journal of Physical Activity and Health*, 9(1), 115-123.

Onywera, V. (2010). Childhood obesity and physical inactivity threat in Africa: Strategies for a healthy future. *Global Health Promotion*, 17(2 Suppl), 45-46.

Onywera, V.O., Adamo, K.B., Sheel, A.W., Waudo, J.N., Boit, M.K. & Tremblay, M. (2012). Emerging evidence of the physical activity transition in Kenya. *Journal of Physical Activity and Health*, 9(4), 554-562.

Page, A., Cooper, A.R., Stamatakis, E., Foster, L.J., Crowne, E.C., Sabin, M. & Shield, J.P. (2005). Physical activity patterns in nonobese and obese children assessed using minute-by-minute accelerometry. *International Journal of Obesity*, 29(9), 1070-1076.

Ramirez-Rico, E., Hilland, T.A., Foweather, L., Fernández-Garcia, E. & Fairclough, S.J. (2014). Weekday and weekend patterns of physical activity and sedentary time among Liverpool and Madrid youth. *European Journal of Sport Science*, 14(3), 287-293.

Sigmund, E., Sigmundová, D., Snoblová, R. & Gecková, A.M. (2014). ActiTrainer-determined segmented moderate-to-vigorous physical activity patterns among normal-weight and overweight-to-obese Czech schoolchildren. *European Journal of Pediatrics*, 173(3), 321-329.

Steyn, K. & Damasceno, A. (2006). Lifestyle and related risk factors for chronic diseases. In D.T. Jamison, R.G. Feachem & M.W. Makgoba (Eds.), *Disease and Mortality in Sub-Saharan Africa* (2nd ed.) (pp. 247-266). Washington, DC: World Bank.

Tremblay, M.S., Colley, R.C., Saunders, T.J., Healy, G.N. & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition, and Metabolism*, 35(6), 725-740.

Treuth, M.S., Schmitz, K., Catellier, D.J., McMurray, R.G., Murray, D.M., Almeida, M.J., Going, S., Norman, J.E. & Pate, R. (2004). Defining accelerometer thresholds for activity intensities in adolescent girls. *Medicine and Science in Sports and Exercise*, 36(7), 1259-1266.

Tudor-Locke, C., Lee, S.M., Morgan, C.F., Beighle, A. & Pangrazi, R.P. (2006). Children's pedometer-determined physical activity during the segmented school day. *Medicine and Science in Sports and Exercise*, 38(10), 1732-1738.

Unwin, N., Setel, P., Rashid, S., Mugusi, F., Mbanya, J.C., Kitange, H., Hayes, L., Edwards, R., Aspray, T. & Alberti, K.G. (2001). Noncommunicable diseases in Sub-Saharan Africa: Where do they feature in the health research agenda? *Bulletin of the World Health Organization*, 79(10), 947-953.

World Health Organization (2010). *Global Recommendations on Physical Activity for Health.* Geneva: WHO.