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Health-related quality of life and lifestyle behaviour clusters in school-aged children from 12 countries.

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ABSTRACT

Objective:

To evaluate the relationship between children's lifestyles and health-related quality of life, and to explore whether this relationship varies among children from different world regions.

Study Design:

This study used cross-sectional data from the International Study of Childhood Obesity, Lifestyle and the Environment. *Participants:* Children (9-11 years) from sites in 12 nations (n=5759). *Measures:* 24-hour accelerometry and self-reported diet and screen time were clustering input variables. Health-Related Quality of Life was self-reported using KIDSCREEN-10. *Analysis*: Cluster analyses (using compositional analysis techniques) were performed on a site-wise basis. Lifestyle behaviour cluster characteristics were compared between sites. The relationship between cluster membership and health-related quality of life was assessed using linear models.

Results:

Lifestyle behaviour clusters were similar across the 12 sites, with clusters commonly characterized by: (1) high physical activity (*Actives*); (2) high sedentary behaviour *(Sitters)*; (3) high screen time/unhealthy eating pattern *(Junk-Food Screenies);* (4) low screen time/healthy eating pattern and moderate physical activity/sedentary behaviour *(All-Rounders).* Health-related quality of life was highest in the All-Rounders cluster.

Conclusions:

Children from different world regions clustered into groups of similar lifestyle behaviours. Cluster membership was related to differing health-related quality of life, with children from the All-Rounders cluster consistently reporting highest health-related quality of life at sites around the world. Findings support the importance of a healthy combination of lifestyle behaviours in childhood: low screen time, healthy eating pattern and balanced daily activity behaviours (physical activity and sedentary behaviour).

Health-related quality of life and lifestyle behaviour clusters in school-aged children from 12 countries.

INTRODUCTION

Health-related quality of life (HRQoL) is an important indicator of children's physical, mental and social wellbeing [1, 2]. Self-reported HRQoL is widely studied among children with chronic diseases or specific health conditions (e.g. [3]). In addition, studies have begun to investigate the relationship between HRQoL and lifestyle behaviours, such as physical activity (PA) and diet [4-8].

Children's HRQoL has been positively associated with PA, sleep and healthy diet, and negatively associated with screen time [4-8]. These studies have examined lifestyle behaviours as individual entities, without considering their interdependence [9]. The relationship between *patterns* of lifestyle behaviours and children's HRQoL has, to our knowledge, only been investigated in two previous studies. First, Hunt et al [10] examined clusters of time use among Irish 15-19 year-olds, reporting higher HRQoL in girls with moderate study/higher leisure (including both PA and screen time) (61% chance of spending time in school-related study, and an average of 3 h:44 min leisure), compared to a higher study/lower leisure time group (85% chance of school-related study, and 5 h:22 min leisure). Second, a study of rural Australian girls (12-15 y) identified two clusters from time-use data, with higher HRQoL in a cluster with high levels of sport/school-related activity/TV/sleep compared to a cluster lower in HRQoL with high computer use/video gaming [11]. These findings suggest that HRQoL differs across lifestyle clusters, yet the results should be considered in the context of certain limitations. First, clusters were based on time use only, and did not consider other lifestyle behaviours. Unhealthy dietary behaviours, for example, are linked to lower HRQoL [5], and have been shown to co-occur with high screen time and low PA [12]. Second, the closed nature and subsequent multi-collinearity of time use was not accounted for in the statistical analyses. Time is finite, subject to a constant sum restraint (i.e. time spent in behaviours must always sum to 24 h/day). Recent methodological literature recommends compositional analysis [13] to take into account that if more time is spent in one behaviour then there must be a correspondingly lower amount of time spent in one or more of the remaining behaviours.

Notably, previous research on children's HRQoL and lifestyle behaviours has almost exclusively been conducted in high-income nations. It is generally accepted that there are discrepancies in the way children from different cultures rate their own health and well-being [14]. Two recent multi-national studies of children's subjective well-being found that while there tended to be a positive correlation between a country's socioeconomic status and subjective well-being, differences in well-being were most likely to be linked to individual-level factors (home situation) and area-level factors (school), rather than country-level factors [Gross Domestic Product (GDP), Human Development Index (HDI)] [14, 15]. Such findings suggest that the influence of individual- and area-level factors on children's well-being may vary between countries. Due to the lack of comparable HRQoL research, it is not possible to determine if children's self-reported HRQoL differs across world regions. However, we can speculate that such variations are present, considering, for example, that poor HRQoL has consistently been linked with obesity in many high-income countries [16]; however, no relationship was detected in a Kuwaiti population [17], and an inverse relationship has been reported in Fijian children [18].

Observation of secular trends in children's PA, sedentary behaviour and diets has identified a progressive "westernisation" in many low-middle income nations, particularly in urban environments [19-21]. Specifically, a decline in PA, increase in screen time and an increasing intake of "junk" foods have been widely reported in low-middle income nations [20, 22]. An understanding of children's lifestyle behaviour patterns and the links with HRQoL is crucial for policy development and proactive planning.

This study aims to address a number of gaps in the extant literature by using a large, multi-national dataset to: (1) describe children's HRQoL across sites in 12 different nations, (2) explore how school-aged children cluster in lifestyle behaviour groups using a comprehensive range of behaviours, and applying compositional analysis techniques, and (3) explore the associations between HRQoL and membership of clusters.

METHODS

Data from the cross-sectional International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) were used. A detailed description of the ISCOLE protocol can be found in Katzmaryzk et al [23].

Participants

Participants were recruited from schools in study sites spread across 12 countries (Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South

Africa, England, and the United States). Of these schools, children aged 9-11 years were invited to participate. Data collection spanned from September 2011 to December 2013.

A sex-balanced sample of approximately 500 children from each site contributed to the final sample of 7372. To be included in the subsequent analyses, participants were required to have complete HRQoL, accelerometry, screen time, eating pattern and sociodemographic covariate data, yielding a final sample of 5759 children (3168 girls and 2591 boys). Excluded participants were more likely to be male ($p<0.001$), have parents of lower education ($p<0.001$), and have more siblings ($p<0.001$) than included participants. Excluded participants also differed from included participants by higher screen time ($p<0.001$), zBMI ($p<0.001$) and higher unhealthy eating pattern ($p<0.001$).

Ethics

Ethical approval was obtained from the Institutional Review Board of the Pennington Biomedical Research Center in Baton Rouge, Louisiana, USA, by the ISCOLE coordinators. Site-specific ethical approval was also received at each participating study site. Parental written informed consent and child assent were obtained as required by local review boards.

Measurement

Health-Related Quality of Life

Child participants completed the KIDSCREEN-10 [24] to provide a global measure of their HRQoL. The KIDSCREEN-10 is the validated brief form of a Europe-wide measure developed using a participatory approach across 13 countries, with and for children aged 8 to 18 years. It comprises 10 questions related to respondents' physical activity, energy and fitness, moods and emotions, social and leisure participation, social and family relationships, cognitive capacity, and school experience. Responses are recorded on a 5-point response scale, and reversed where necessary to ensure that higher scores indicate better HRQoL. In countries where the KIDSCREEN-10 had not previously been used, the questions were systematically translated to the local language following rigorous procedures outlined by Kidscreen [25]. Items for each participant were summed and used to calculate Rasch person-parameters, which were subsequently transformed into T-values with a mean of 50 and a standard deviation of approximately 10 [24].

Lifestyle behaviours

Daily activities (light, moderate and vigorous PA, sedentary behaviour and sleep) were measured objectively by 24 h, 7-day accelerometry. Participants were instructed to wear an Actigraph GT3X+ accelerometer (ActiGraph LLC, Pensacola, FL, USA) on their right hip. The mean daily wear-time was 22.8 h. To be included, participants were required to have ≥10 h per day waking wear time (on at least 4 days, including at least one weekend day) and ≥160 min total sleep period for at least 3 nights (including one weekend night) [26]. Activity was sampled at 80Hz and downloaded in 1-sec epochs, which were aggregated into 60-s epochs to estimate nocturnal sleep duration via a previously published algorithm [27]. Waking-wear time was processed in 15-s epochs to determine time vigorous, moderate and light PA and sedentary behaviour, as defined by Evenson [28]. Each component (sedentary behaviour and light, moderate and vigorous PA and sleep) was weighted for weekdays:weekend days at 5:2.

Participants reported typical weekday and weekend day non-school time spent (1) watching TV and (2) playing computer or video games in categories of: none; <1 h;1 h; 2 h; 3 h; 4 h; ≥5 h. Both TV and video/computer time were combined to form a continuous variable representing 'screen time'. Typical weekday and weekend day screen time were weighted at 5:2 to create an average daily screen time score, which was then normalised by a square root transformation.

Child participants' responses to a Food Frequency Questionnaire (FFQ) of moderate reliability and low-to-moderate validity were used to assess eating patterns [23, 29]. A total of 23 food categories (with culturally relevant examples of individual food items, as determined by researchers at the study sites) were included in the FFQ. Principal component analyses using FFQ food groups as input variables were interpreted to identify two factors: (1) a healthy eating pattern (positive loadings for vegetables, fruit, whole grains, etc.), and (2) an unhealthy eating pattern (positive loadings for fast food, soft drinks, sweets, etc.). Scores representing healthy eating pattern and unhealthy eating pattern were calculated for each participant.

Sociodemographics

Parents completed a questionnaire [23] which gathered details including the child's sex, family composition (number of siblings and number of parents) and highest level of education achieved by either parent (1=<high school and some high school; 2=completed high school and some post-secondary (e.g. vocational diploma or

certificate); 3=bachelor degree and post-graduate) . Body mass index (BMI) was calculated [BMI=weight (kg)/height (m^2)] from objectively measured weight (TANITA Corporation, Tokyo, Japan [30]) and height (Seca 213 portable stadiometer, Hamburg, Germany), and then transformed to z-scores using age- and sex-specific World Health Organization reference data [31].

Data analysis

Data analysis consisted of (1) describing children's HRQoL by study site, (2) identification of site-specific lifestyle behaviour clusters and (3) examining the relationship between HRQoL and cluster membership on a site level.

Cluster analyses were performed with R (R Development Core Team, Vienna, Austria). Compositional data (24-h accelerometry) were transformed to isometric logratio co-ordinates [32]. Isometric logratios are recommended for cluster analysis of compositional data because they are non-collinear and multivariate (i.e., they carry information regarding the relative proportions of the components). Importantly, Euclidean distance between isometric logratio co-ordinates is a measure coherent with the relative nature of compositional data [32, 33].

Children's lifestyle behaviours were used to determine clusters on a by-site basis: z-scores of 24-h time use (i.e., isometric log ratios); screen time; and healthy and unhealthy eating scores. Agglomerative hierarchical clustering was used to plot a dendrogram (using Ward's method and squared Euclidean distances) for the interpretation of potential cluster structure and number [34]. Subsequently, a k-means partitioning cluster analysis was used. An optimal number of four clusters was identified in most sites based on analysis of the dendrograms and the interpretability of cluster solutions derived from the k-means procedures. To assess the invariance of the cluster solution, a random subsample from each site's cohort (n=half of each site's sample) was clustered using the same procedure. Agreement between solutions was substantial (Cohen's kappa: range 0.71 – 0.95, median=0.84). Components of 24-h time use were described using compositional means to represent the centre of the compositional data points (geometric means adjusted to total 1440 min) [13, 35]. Screen time and eating pattern scores were described using arithmetic means and standard deviations.

Children's HRQoL was compared across lifestyle behaviour clusters on a site-wise basis using analysis of covariance [Stata/IC 14.0 (StataCorp LP, USA)] with adjustment for zBMI, sex, parental education and family structure, and the nested sampling design using linearized variance estimation (svy).

RESULTS

Participant characteristics are presented in Table 1. Children's self-reported HRQoL differed between sites (Table 2). Children from higher income countries tended to report higher HRQoL than children from low-to-middle income countries (correlation between HRQoL and world bank classification: r=0.74, p=0.01, and between HRQoL and human development index: r=0.62, p=0.03).

****insert Table 1 about here****

****insert Table 2 about here****

Cluster characteristics

Three clusters were identified across most of the sites (Table 3), with each of the 12 sites having; a high sedentary behaviour/low PA cluster (*Sitters*), a cluster characterised by high PA/low sedentary behaviour (*Actives*, *Retro-Actives* or *Techno-Actives; Retro* indicating low screen, and *Techno* indicating high screen), and a cluster with a combination of high screen time and unhealthy eating pattern (labeled *Junk Food Screenies* or *Junk Food Techno-Actives*). A fourth *All-Rounders* cluster (low screen, healthy eating pattern and moderate PA/sedentary behaviour) was identified in 9 out of 12 sites. Sleep generally did not influence clusters determination.

****insert Table 3 about here****

Relationship between Health-Related Quality of Life and cluster membership

Similar relationships between HRQoL and cluster membership were observed across sites, regardless of the country's HDI (Table 3). Children in the *All-Rounders* cluster reported the highest HRQoL in 7 of 9 sites in which this cluster was identified (Australia, Canada, China, Finland, India, Portugal and England). The *All-Rounders'* HRQoL was significantly higher than Sitters' HRQoL in 7 out of 9 sites, and higher than Actives' HRQoL in 5 out of 9 sites. Effect sizes (Cohen's) between clusters with highest and lowest HRQoL were generally moderate (Table 4).

****insert Table 4 about here****

DISCUSSION

Remarkable commonality was observed in lifestyle behaviour patterns throughout the world, each country having a cluster characterised by (1) high sedentary behaviour, (2) high PA and (3) a combination of high screen time and unhealthy eating pattern. Relationships between HRQoL and lifestyle behaviours were similar throughout the world, *All-Rounders* consistently reporting higher HRQoL than *Sitters* and *Actives*.

Sleep duration was generally unimportant in the determination of lifestyle behaviour clusters, possibly due to parental influence mediating relative homogenous sleep durations in this age group. Previous cluster analyses have rarely included sleep duration, and none have used compositional analysis techniques, therefore further research is required to explore the role of sleep in determining children's lifestyle clusters. Because clusters in this study were not differentiated by sleep duration, the contribution of sleep duration to the relationship between HRQoL and children's lifestyles cannot be determined.

The similarity of lifestyle behaviour patterns identified in children across the world is striking. It could be expected, from a historical perspective, that children from lower-income countries would be more active and have healthier diets than children from higher-income countries [22]. However, in this study, clusters identified in low- and middle-income countries (e.g. India) were comparable to those of some high-income countries (e.g. England and Australia). The similarity in lifestyle behaviour clusters may simply be due to biological factors. Alternatively, it may reflect a cultural shift towards lower PA, higher screen time and increased fast food consumption as low-and middle-income countries become increasingly westernised [22, 36]. Consistent with this, children recruited in ISCOLE were from urban and suburban centres, where a universal Western "monoculture" might exist. A transition in both PA [22] and nutrition behaviour [40] has been documented in many low- and middle-income countries, and attributed to economic development, global media and food distribution networks and increased reliance on motorised transport [36]. However, the findings of the present study are novel, as to our knowledge, analyses of children in low- and middle-income countries have not explored lifestyle behaviour clusters based on both daily activities and eating patterns. Further studies are required to confirm these observations, particularly considering the generalizability of the present study's findings may be limited due to the nature of cluster analysis and the differences between included and excluded children.

Children identified as *All-Rounders* (healthy eating pattern/low screen/moderate PA and sedentary behaviour) consistently reported the highest HRQoL. This is not surprising, given that both healthy diet [5] and low screen time [6] have consistently been linked to higher HRQoL in previous variable-centered studies. Notably, children with a largely opposite lifestyle behaviour pattern (*Junk Food Screenies*: unhealthy eating pattern/high screen/moderate PA) did not report the lowest HRQoL, except when unhealthy eating pattern and high screen were combined with high PA (Canada: the *Junk Food Techno-Actives*). The relationship between high PA and poor HRQoL is striking, considering PA has previously consistently been positively related to HRQoL [4-6]. In contrast, we found *Actives* generally reported lower HRQoL than *All-Rounders*, and tended to be on par with *Sitters*. In exploring this unexpected finding, we noted that although *All-Rounders* did not have the highest PA, in the majority of cases (6 out of 9) they nevertheless accumulated greater than 60 minutes of MVPA on an average day, in line with guidelines for this age-group [37]. This suggests that 60 minutes may be a threshold above which additional MVPA has no further positive relationship with HRQoL, however this warrants further investigation. Furthermore, the *All-Rounders* lifestyle represents a balance between the components of daily time use, so is possibly free from the stresses and pressures of high involvement in PA, e.g. competitive sport (*Actives*) or sedentary behaviour, e.g. study (*Sitters*). It has previously been suggested that imbalances in time use imposes developmental and emotional costs on adolescents [38]. By considering the influence of combinations of behaviours rather than individual behavioural effects, our research moves beyond the majority of previous studies to consider behaviours in the context of a child's overall lifestyle.

Strengths and Limitations

This study had several important strengths. The results were based on a large multinational dataset encompassing many socioeconomic, cultural and geographic contexts. Daily activities were objectively measured and analysed using compositional techniques. Children's HRQoL was captured using a 10-item tool previously validated for school-aged children. Analyses adjusted for many potential confounders, including zBMI.

A number of limitations should be considered. First, the study's cross-sectional design precludes determination of causation. Second, although the KIDSCREEN-10 tool has been used in many countries, it was developed for children in European countries, and may reflect HRQoL differently for children from other regions. For this reason, our analyses were carried out on a by-site basis; however, caution must be exercised when comparing HRQoL across countries. Third, while activity was measured objectively, accelerometry may not differentiate between sitting and standing postures. Furthermore, sleep must be estimated. Other behaviours were self-reported; screen time did not include devices such as tablets or cell phones, and the FFQ had low-moderate validity and moderate reliability. Finally, the results cannot be generalised to other populations due to the exploratory, data-driven nature of cluster analysis. ISCOLE recruited entirely from urban and suburban centres, and results might be quite different for children in rural areas or smaller regional towns.

Implications/Conclusion

In summary, children generally grouped into four lifestyle behaviour clusters, which were surprisingly similar across sites. This may indicate that, particularly in urban and suburban centres, children's lifestyles are converging to contribute to one global monoculture. The best HRQoL was related to a virtuous lifestyle of low screen, healthy eating pattern and balanced time use (moderate PA/sedentary behaviour), i.e., the *All-Rounders*. Clusters with the highest PA (*Actives*) or highest sedentary behaviour (*Sitters*) were most often associated with the lowest HRQoL. This suggests that in terms of activity behaviours, relative balance may contribute to HRQoL.

Lifestyle behaviours established in childhood are known to influence health and wellbeing in later years, for example, unhealthy behaviours are linked with future risk of being overweight/obese [39] and cardiovascular disease [40]. Interventions should focus on the combination of healthy diet and restricted screen time. Such interventions should be a priority in low- and middle-income countries, where there is evidence of lifestyle transition towards unhealthy behavior patterns [22]. Studies examining HRQoL and its relationship with potentially modifiable contributors should be a priority of future research.

ABBREVIATIONS

PA: Physical activity

HRQoL: Health-related quality of life

ISCOLE: International Study of Childhood Obesity, Lifestyle and the Environment

FFQ: Food frequeny questionnaire

BMI: Body Mass Index

TV: Television

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Table 1: Descriptive characteristics of participants.

Characteristic		Included n=5759	Excluded n=1613	*p*
Gender, %	Male	2591 (45)	831 (52)	<0.001
	Female	3168 (55)	782 (48)	
Highest parental education, %	1	1133 (20)	267 (17) $^{n=1214}$	<0.001
	2	2434 (42)	541 (34)	
	3	2192 (38)	406 (25)	
Number of parents, n (%)	≤1	1056 (18)	323 (20)	0.114
	≥2	4703 (82)	1290 (80)	
Number of siblings, n (%)	0	1034 (18)	207 (13)	<0.001
	1	2411 (42)	444 (28)	
	2	1297 (23)	319 (20)	
	3	538 (9)	155 (10)	
	≥4	479 (8)	488 (30)	
zBMI, mean (sd)		0.44 (1.25)	0.61 (1.29) $^{n=1582}$	<0.001
HRQoL (T-score), mean (sd)		50.12 (9.61)	49.58 (10.0) $^{n=1538}$	0.05
Time use (min/day), compositional mean	Sleep	539*	536 $^{n=339}$	0.08$^{\$}$
	SB	525	524 $^{n=794}$	

	LPA	320	322 n=794	
	MPA	41	42 n=794	
	VPA	15	15 n=794	
Screen time (h/day), mean (sd)		2.5 (1.9)	2.8 (2.2) n=1568	<0.001
Eating pattern, mean (sd)	Healthy	-0.00 (0.99)	0.00 (1.02) n=1440	1.00
	Unhealthy	-0.07 (0.93)	0.27 (1.12) n=1440	<0.001

No standard deviations presented for compositional means because univariate variability is irrelevant for compositional data. [$]Daily time use compositions (transformed to isometric log ratio co-ordinates) were compared using Hotelling's T square test (MANOVA). SB = sedentary behaviour. LPA = light physical activity. MPA = moderate physical activity. VPA = vigorous physical activity. zBMI=Body mass index z-score (World Health Organization). HRQoL = health-related quality of life. Parent education levels are 1= < high school and some high school; 2 = completed high school and some post-secondary (e.g., vocational diploma or certificate); 3 = bachelor degree and post-graduate).

Site (City)	**Health-Related Quality of Life***	**Human Development Index ****	**World bank classification*****
Australia (Adelaide)	49.85 (8.54)	0.929 (Very High)	High income
Canada (Ottawa)	51.25 (9.29)	0.908 (Very High)	High income
Finland (Helsinki, Espoo & Vantaa)	52.67 (8.67)	0.882 (Very High)	High income
Portugal (Porto)	52.91 (10.14)	0.809 (Very High)	High income
England (Bath & North East Somerset)	50.03 (8.77)	0.863 (Very High)	High income
United States (Baton Rouge)	50.63 (10.24)	0.91 (Very High)	High income
Brazil (São Paulo)	47.31 (7.80)	0.718 (High)	Upper-middle income
Colombia (Bogotá)	49.92 (8.15)	0.71 (High)	Upper-middle income
China (Tianjin)	51.21 (11.54)	0.687 (Medium)	Upper-middle income
India (Bangalore)	48.16 (9.21)	0.547 (Medium)	Lower-middle income
South Africa (Cape Town)	50.03 (11.41)	0.619 (Medium)	Upper-middle income
Kenya (Nairobi)	47.13 (9.95)	0.509 (Low)	Low income

*Values presented as arithmetic mean (standard deviation). **Human Development Index obtained from United Nations Development Programme. Human Development Report 2011. Sustainability and Equity: A Better Future for All. New York NY: Palgrave Macmillan; 2011. ***obtained from World Bank. World Development Indicators 2012. Washington, DC: The World Bank; 2012

Table 2: Children's Health-Related Quality of Life by site and Human Development Index.

Table 3: Characteristics of lifestyle behaviour clusters.

Australia		Compositional mean: min/d					Mean: h/d (sd)	Mean
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet***
Sitters	24 (105)	574	544	282	29	11	2.7 (1.6)	-0.33 (0.88)
Actives	23 (98)	584	413	355	56	32	2.3 (1.3)	-0.34 (0.87)
Junk Food Screenies	23 (99)	565	494	311	45	25	4.3 (1.6)	-0.13 (1.08)
All-Rounders	30 (127)	571	488	312	44	24	1.4 (1.0)	0.64 (0.82)
Brazil								
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet**
Retro-Actives	31 (134)	526	464	375	52	23	2.0 (1.3)	-0.03 (0.97)
Sitters	29 (127)	528	569	310	25	8	3.0 (2.0)	-0.05 (0.94)
Junk Food Techno-Active	13 (56)	513	482	369	51	24	4.9 (2.8)	0.28 (1.17)
Techno-Active	27 (118)	515	521	338	46	20	5.6 (2.0)	-0.05 (1.00)
Canada								
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet**
Junk Food Screenies	31 (152)	539	521	322	42	16	3.8 (2.1)	-0.82 (0.77)
Junk Food Techno Actives	4 (22)	561	480	326	52	21	3.6 (2.6)	-0.17 (1.20)
Sitters	27 (136)	546	580	274	30	10	1.7 (1.5)	0.26 (0.84)
All-Rounders	37 (185)	565	483	319	50	23	1.4 (1.1)	0.50 (0.81)
China								
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet**
Junk Food Screenies	10 (47)	537	522	326	39	16	3.1 (2.3)	0.50 (1.07)
All-Rounders	23 (104)	535	548	310	35	12	0.9 (0.9)	0.95 (0.79)

Actives	36 (167)	526	546	314	38	16	2.3 (1.7)	-0.53 (0.66)
Sitters	31 (140)	521	638	252	22	7	1.4 (1.3)	-0.24 (0.87)

Colombia

	% (n)	Sleep	SB	LPA	MPA	VPA	Screen Time	Healthy Diet
Low sleep	30 (244)	512	555	311	46	16	2.7 (1.4)	0.15 (1.04)
Sitters	20 (161)	533	562	308	30	7	3.0 (1.6)	-0.18 (0.81)
Junk Food Techno-Actives	22 (180)	529	463	363	62	24	4.2 (1.5)	-0.38 (0.89)
All-Rounders	29 (235)	539	452	363	62	24	1.7 (0.9)	0.26 (1.04)

England

	% (n)	Sleep	SB	LPA	MPA	VPA	Screen Time	Healthy Diet
Junk Food Screenies	25 (94)	553	504	310	48	25	4.6 (1.9)	-0.42 (0.89)
Actives	23 (87)	597	448	317	51	27	2.0 (1.0)	-0.32 (0.69)
Sitters	23 (84)	584	561	254	30	11	2.9 (1.3)	-0.47 (0.82)
All-Rounders	29 (108)	572	516	285	46	21	2.0 (1.1)	0.99 (0.71)

Finland

	% (n)	Sleep	SB	LPA	MPA	VPA	Screen Time	Healthy Diet
Actives	35 (150)	515	506	325	61	33	2.9 (1.6)	-0.36 (0.68)
All-Rounders	28 (122)	529	542	298	48	24	1.5 (1.0)	1.00 (0.84)
Sitters	32 (139)	515	600	276	36	13	3.0 (1.7)	-0.51 (0.67)
Junk Food Screenies	5 (21)	539	494	322	57	28	4.8 (1.9)	0.18 (1.33)

India

	% (n)	Sleep	SB	LPA	MPA	VPA	Screen Time	Healthy Diet
All-Rounders	23 (119)	519	524	349	35	12	0.9 (0.6)	1.12 (0.68)
Sitters	35 (183)	510	583	316	24	7	1.7 (1.2)	-0.32 (0.75)
Junk Food Screenies	13 (59)	535	475	366	46	18	3.2 (2.2)	0.40 (1.01)
Actives	31 (165)	526	482	367	47	19	1.5 (0.9)	-0.60 (0.66)
Kenya								
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet**
Retro-Active	27 (123)	518	471	352	65	34	1.4 (1.4)	-0.77 (0.76)
Lightly Active	29 (130)	531	494	362	39	14	2.0 (1.3)	0.23 (0.82)
Junk Food Techno-Actives	22 (98)	516	481	350	62	31	3.3 (2.2)	0.66 (0.82)
Sitters	22 (99)	521	591	282	33	14	2.4 (1.4)	-0.01 (1.04)
Portugal								
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet**
All-Rounders	29 (164)	511	555	312	42	19	1.8 (1.3)	1.02 (0.59)
Actives	30 (166)	497	541	332	48	22	1.8 (1.0)	-0.72 (0.58)
Sitters	28 (158)	518	610	278	26	8	2.0 (1.4)	-0.21 (0.84)
Junk Food Screenies	13 (74)	491	569	315	45	20	3.8 (2.0)	-0.21 (1.00)
South Africa								
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet**
Low Food Intake	27 (99)	558	511	310	43	18	3.2 (2.0)	-0.75 (0.72)
Sitters	25 (92)	554	555	295	28	8	2.1 (1.6)	0.33 (0.97)
Retro-Actives	23 (81)	563	428	360	62	28	1.5 (1.4)	-0.07 (1.01)
Junk Food Screenies	25 (89)	552	476	339	54	20	4.6 (2.3)	0.55 (0.75)

United States								
	% (n)	**Sleep**	**SB**	**LPA**	**MPA**	**VPA**	**Screen Time**	**Healthy Diet**
Sitters	21 (88)	537	593	283	22	6	3.7 (2.3)	-0.07 (1.02)
Actives	27 (113)	538	494	348	42	18	3.6 (2.4)	-0.77 (0.51)
All-Rounders	36 (150)	550	532	306	34	17	1.4 (0.9)	0.31 (0.83)
Junk Food Screenies	16 (67)	520	502	354	44	20	5.0 (3.1)	0.70 (1.10)

No standard deviations presented for compositional means as univariate variability is irrelevant for compositional data. SB = sedentary behaviour. LPA = light physical activity. MPA = moderate physical activity. VPA = vigorous physical activity. HRQoL = health-related quality of life. *Diet refers to eating pattern score. Superscript denotes statistically significant pairwise comparisons (following Bonferroni correction of p<0.008). All linear models are adjusted for body mass index z-score, gender, parental education, number of parents, number of siblings and potential clustering at school level.

Table 4: Ranking of clusters at each site according to HRQoL. The effect size compares the groups with the highest and lowest HRQoL.

	Australia	**Brazil**	**Canada**	**China**	**Colombia**	**England**	**Finland**	**India**	**Kenya**	**Portugal**	**RSA**	**USA**
All-Rounders	1+		1+	1+	1	1+	1+	1+		1+		2+
Junk Food Screenies	3-		3-	2		3	2	2		2	1+	1+
Actives	2			4-		2	3-	4-		4-		3-
Sitters	4-	1	2-	3-	4	4-	4-	3-	4-	3-	2	4-
Junk Food Techno-Actives		2	4-		3				2			
Lightly-Actives									1+			
Retro-Active		4							3		3	

s												
Low Food Intake											4-	
Techno-Actives		3										
Low Sleep					2							
Effect size	0.59	0.22	0.83	0.61	0.17	0.50	0.41	0.66	0.44	0.39	0.44	0.48

RSA=Republic of South Africa. USA=United States of America. + denotes significantly higher Health-Related Quality of Life (HRQoL) than -, with values1 to 4 indicating highest to lowest HRQoL. Cohen’s effect size calculated between clusters with highest and lowest health-related quality of life, following adjustment for covariates.