

The impact of school-day variation in weight and height on National Child Measurement Programme BMI-determined weight category in Year 6 children

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Abstract

Background: In England, the National Child Measurement Programme (NCMP) annually measures the weight and height of Year 6 schoolchildren (age 10-11 years). Whilst measurement protocols are defined, the time of measurement within the school day is not. This study examined the impact of school-day variation in weight and height on NCMP BMI-determined weight category in Year 6 children. Methods: Standing height and weight were measured in morning and afternoon sessions in 74 children, boys ($n = 34$; height: 141.16 ± 7.45 cm; weight: 36.48 ± 9.46 kg, BMI: 18.19 ± 3.98 kg.m²) and girls ($n = 40$; height: 144.58 ± 7.66 cm; weight: 42.25 ± 11.29 kg; BMI: 19.97 ± 3.98 kg.m²) aged 11 ± 0.3 years. Results: In the whole sample, height decreased (mean diff -0.51 cm, 95% CI: -0.39 to -0.64 cm, $p = 0.01$), weight did not change (Mdn = 36.40 to 36.35, $p = 0.09$) and BMI increased (Mdn = 18.04 to 18.13, $p = 0.01$). In girls weight increased (Mdn = 41.40 to 41.60, $p = 0.01$). BMI percentile increased (Mdn = 57th centile to Mdn = 59.5th centile, $p = 0.01$). One girl increased in BMI category from morning to afternoon according to the clinical cut-off's ($\leq 2^{\text{nd}}$, $> 91^{\text{st}}$ & $> 98^{\text{th}}$) and three girls increased BMI category according to the population monitoring cut-off's ($\leq 2^{\text{nd}}$, $\geq 85^{\text{th}}$, $\geq 95^{\text{th}}$). Conclusions: School-day variation in height (and in girls alone, weight) impact upon increased BMI & BMI percentile in afternoon versus morning measurements in Year 6 children. Although not reaching statistical significance, resultant variation in categorisation at the individual level may lead to unwarranted follow-up procedures being initiated. Further research with larger samples is required to

further explore the impact of daily variability in height & weight upon both clinical and population monitoring BMI-determined weight status categorisation in the NCMP.

Keywords: *Diurnal variation, anthropometry, measurement reliability, overweight, obesity*

Introduction

The National Child Measurement Programme (NCMP) is a countrywide public health surveillance initiative, operated jointly by the Department of Health (DoH) and the Department of Education (DoE), in England. Annually, school children in Reception (4-5 years) and Year 6 (10-11 years) have their height and weight measured. These results are used by the National Health Service (NHS) to inform local planning and delivery of services for children, and to gather population based data to produce growth trends and ascertain the prevalence of *overweight* and *obese* school children (NHS Information Centre, 2009).

All measurements are conducted according to a defined measurement protocol (Cross-Government Obesity Unit, 2009), however the guidelines do not specify a specific time of day at which the measurements should be conducted (i.e. am or pm). The NCMP use measurements of height and weight to calculate Body Mass Index (BMI). For the purpose of reporting population prevalence estimates the NCMP categorise the weight status of children according to age and gender specific 'population monitoring' BMI cut-offs from the 1990 UK growth reference dataset (Cole, Freeman, & Preece, 1995): *Underweight* = $\text{BMI} \leq 2^{\text{nd}}$ centile; *Healthy weight* = $> 2^{\text{nd}}$ centile to $< 85^{\text{th}}$ centile; *Overweight* = $\geq 85^{\text{th}}$ centile to $< 95^{\text{th}}$ centile; *Obese* = $\geq 95^{\text{th}}$ centile. When

reporting individual children's results in parental feedback letters the NCMP use 'clinical' BMI cut-off's from the 1990 UK growth reference dataset: *Underweight* = BMI \leq 2nd centile; *Healthy weight* = $>$ 2nd centile to \leq 91st centile; *Overweight* = $>$ 91st centile to \leq 98th centile and *Very Overweight* (The term *Very Overweight* is used by the NCMP for parental feedback as an alternative to *Obese*) = $>$ 98th centile.

The Primary Care Trust responsible for the delivery of the NCMP in their geographic area then either routinely, or on a request only basis, send parents and guardians of children measured by the NCMP a letter informing them of their child's weight status. In the guidance letter template provided to the PCT by the NCMP, those parents/guardians with children classified as *underweight*, *overweight* or *very overweight* are invited to contact their local Primary Care Trust (PCT) and/or make use of local PCT weight-relevant health initiatives.

The ramifications of potential misclassification, or misclassification caused by unstandardised measurement procedures are critical on an individual level. Children labelled with a pejorative term such as *overweight* or *very overweight* are more likely to encounter social discrimination by peers and be at greater risk of anxiety, depression, disturbed eating, reduced physical activity and size harassment (Puhl & Latner, 2007). This could potentially lead to a *healthy weight* child (misclassified as *overweight*) developing a negative body image and engaging in unhealthy weight and inappropriate weight loss attempts (Szwarc, 2004). Conversely the misclassification of an *overweight* child as *very overweight* may serve only to further exacerbate their condition, leading to negative implications for physical health including unhealthy eating patterns and avoidance of physical activity (Haines, Neumark-Sztainer, & Eisenberg, 2006). As the

classification of children's weight category via BMI by the NCMP is currently receiving significant media, public health and clinical attention, it is essential to consider and quantify the impact of both technical and biological variation on the classification of weight status in children.

The accurate and reliable measurement of height is important for the assessment of growth in children (Voss, Bailey, Cumming, Wilkin & Betts, 1990). Past research has focused upon sources of error attributable to the measurement instrument, the observer, the measurement protocol and the participant (Voss et al., 1990; Voss & Bailey, 1997). A source of bias that is known to be significant is the diurnal variation of height. It has long been observed that height alters throughout the day, lengthening during sleep and shortening during waking hours (De Puky, 1935) attributed both to changes in the water content of the inter-vertebral discs (Adams, Dolan, & Hutton, 1987) and compression of inter-vertebral cartilage and loading of the inter-vertebral discs (Park, 1997).

Diurnal height loss has been reported in a number of studies of children and adolescents (Whitehouse, Tanner, & Healy, 1974; Voss et al., 1990; Lampl, 1992; Voss & Bailey, 1997; Siklar, Sanli, Dallar, & Tanyer, 2005). One of the early studies by Whitehouse et al. (1974) measured 11 boys (age: 12-14 years) at 1000 and 1700 on four occasions, 3-4 months apart. A further 19 boys (age: 12-14 years) were measured at 0930 and 1400 on a single occasion. A significant difference of 0.2 cm (95% range: -0.1 to 0.6 cm) was observed in height between subjects over the half day measures (0930-1400); however the mean change of 0.46 cm (0 to 1 cm) across the whole day (1000-1700) was not significant ($p > 0.05$). As the standard error of measurement was reported as ± 0.18 cm, it was concluded that diurnal variation in height was likely due to measurement error

(i.e. positioning of the child), as opposed to an actual decrease in height. In a larger sample, Voss and Bailey (1997) measured fifty three children (age: 3-11 years) in a single day. Each subject was measured on four occasions (0900, 1100, 1300 & 1500) by two observers, in a random order, using both a stretched and an un-stretched technique. As per previous studies, the greatest height loss reported was in the morning, and the largest decrement was between the hours of 0900-1100 (Whitehouse et al., 1974). Compared to the un-stretched measurements, the stretched technique increased the height measurement by ~0.3 cm. However mean height loss over the whole six hour period was similar for both un-stretched 0.551 cm (range: -0.6 to 1.8 cm) and stretched 0.555 cm (-0.4 to 1.9 cm) measurements.

More recently a large sample of Turkish children ($n = 478$, age: 9.9 ± 2.3 years) were measured twice in one day between 0900-1000 and 1500-1600, by one observer (Siklar et al., 2005). A significant moderate height loss was found for the whole sample (0.47 ± 0.05 cm; $p < 0.05$) (for girls 0.48 ± 0.04 cm and for boys 0.47 ± 0.08 cm). There was no consensus however as to the expected height loss that may occur in a given individual. Nonetheless the average daily height loss from morning to afternoon/evening has been reported as being between 0.4-1.5cm in child populations (Whitehouse et al., 1974; Voss et al., 1990; Lampl, 1992; Voss & Bailey, 1997; Siklar et al., 2005). More solid conclusions can be made regarding the time of greatest height decrement, which has been consistently reported as during the first three waking hours (Whitehouse et al., 1974; Voss & Bailey, 1997; Tilmman & Clayton, 2001).

In conjunction with body height, it is well accepted that body weight varies within and between days. Fluctuation in body mass is common due to changes in hydration status,

dietary intake, and participation in daily physical activity (Cheuvront, Carter, Montain, & Sawka, 2004). If one considers the additive effect of equipment measurement error, biological variation of both height and body mass and intra/inter-observer error, there is potential for children's BMI category to be misclassified by the NCMP dependant upon the time of when measurements are taken.

To date no studies have investigated concurrent changes in weight and height in direct relation to their impact on BMI weight category. The aims of the current study therefore, were to determine the impact of school-day variation in weight and height on NCMP BMI-determined weight category in Year 6 children and to investigate if the magnitude of any such variation differed between the BMI-determined weight categories.

Methods

Participants

Seventy four Year 6 children ($n = 34$; height: 141.16 ± 7.45 cm; weight: 36.48 ± 9.46 kg, BMI: 18.19 ± 3.98 kg.m²) and girls ($n = 40$; height: 144.58 ± 7.66 cm; weight: 42.25 ± 11.29 kg; BMI: 19.97 ± 3.98 kg.m²) aged 11 ± 0.3 years were recruited from three primary schools in the West Midlands region of England. In loco parentis consent from the school head teacher and/or assumed parental consent were obtained and the study was approved through Institutional ethics procedures.

Study design

Data were collected across four separate school days with standing height (cm) and body mass (kg) measured according to the NCMP protocols between 0900-1045 in the

morning school session (HEIGHT-am, WEIGHT-am) and again between 1320-1450 in the afternoon school session (HEIGHT-pm, WEIGHT-pm). Intra-observer/equipment related measurement error was estimated through repeating the morning measurements within one hour of the original morning measurement in a sub-sample of 35 children.

Procedures

All anthropometric measurements were taken by one researcher and the weighing scale and stadiometer were calibrated on each test day. Participants wore light clothing, removed shoes, hair ornaments, and any objects from their pockets.

Height to the nearest 0.1 cm was measured according to NCMP guidelines (Cross-Government Obesity Unit, 2009) using a freestanding portable stadiometer (Seca 214, Seca Ltd, Leicester, UK). The participant stood fully erect on the footboard, with their back against the vertical surface of the stadiometer, and heels flush against the base. The head was positioned in the Frankfort plane, and the headboard moved down onto the vertex compressing the hair.

Weight to the nearest 0.1 kg was measured according to NCMP guidelines (Cross-Government Obesity Unit, 2009) using electronic weighing scales (HD 352, Tanita Corporation, Tokyo, Japan). The weighing scales were checked to ensure they read zero. The participant was asked to stand on the centre of the scales without support, and with their mass distributed evenly on both feet.

Repeat measurements were performed for each variable at each time of measurement with the second measurement required to be within 0.4 cm or 0.1 kg of the first for

height and weight respectively. Mean values were used for all subsequent analyses (Mirwald et al., 2002).

Participants were measured in a randomised order at each session and were blind to the aims of the study, only being told they would be measured multiple times. The researcher was blind to any previous measurements.

Body Mass Index (BMI)

Body mass index (kg.m^2) was calculated for each measurement session (BMI-am and BMI-pm) by dividing mean weight in kg by the square of mean height in metres. These data were then used to express BMI as a centile based on the British 1990 growth reference data (Cole et al., 1995). Both the population monitoring and clinical BMI cut-off's, as described above, were used to determine participant's BMI weight category. These were expressed as BMI morning session category (BMICATClin-am; BMICATPop-am) and BMI afternoon session category (BMICATClin-pm; BMICATPop-pm).

Assessment of measurement error

To investigate intra-observer measurement error, the standard error of measurement of the difference between the repeated morning measurements in the sub-sample of 35 children was calculated by dividing the standard deviation of the difference by the square root of the number of measurements taken (Lampl, 1992). To assess accuracy, the technical error of measurement (TEM) was calculated as the square root of the sum of the squared differences between the two repeat measures divided by two times the sample size according to Ulijasek & Kerr (1999). The coefficient of reliability, as a

measure of anthropometric precision was calculated as 1 minus the TEM squared divided by the overall SD of the study, squared, according to Goto & Mascie-Taylor (2007). Ulijaszek and Kerr (1999) suggest a cut-off of 0.95 be used (i.e. a human error of up to 5%).

Statistical Analyses

All statistical analyses were performed using SPSS 17.0 (SPSS, Chicago, IL, USA).

To investigate intra-observer measurement error between the morning repeat measurements in the sub-sample of 35 children, intraclass correlation coefficients (ICC) with a two-way random effects model for absolute agreement were used to examine the strength of agreement between replicate measurements (Hopkins, 2000).

In the main study, all mean measurement data and calculated BMI-am and BMI-pm variables were checked for normality of distribution using the Kolmogorov-Smirnov test. WEIGHT-am, WEIGHT-pm, BMI-am and BMI-pm, BMICATClin-am, BMICATPop-am, BMICATClin-pm, BMICATPop-pm, BMICentile-am and BMICentile-pm all violated the normality assumption.

To investigate the difference between HEIGHT-am and HEIGHT-pm a paired samples t-test was used. To investigate differences between WEIGHT-am and WEIGHT-pm, BMI-am and BMI-pm, and BMI percentile-am and BMI percentile-pm Wilcoxon signed rank tests were used.

Change in BMICATClin-am to BMICATClin-pm and BMICATPop-am to BMICATPop-pm was investigated using Wilcoxon signed ranks tests, and individual

level analysis. To investigate change from HEIGHT-am to HEIGHT-pm, WEIGHT-am to WEIGHT-pm, BMI-am to BMI-pm, and BMICentile-am to BMICentile-pm between BMI-am weight category groups using both BMI cut-off's, Kruskal Wallis tests were used with Mann-Whitney U tests as post hoc tests where necessary.

The alpha level for statistical significance was set at $p < .05$ for all tests. If a difference was found, the effect size was calculated. For parametric tests partial eta squared (small = 0.01, medium = 0.06, large = 0.14) was calculated. For non-parametric tests the approximate r statistic was calculated (small = 0.1, medium = 0.3, large = 0.5, Cohen, 1988).

Results

Intra-observer measurement error

Results from the intra-observer measurement error sub-sample analyses can be found in Table I.

****Table I here***

The TEM was primarily used to quantify measurement error. Ulijaszek & Lourie (1994) suggest that for 10-11 year old children the acceptable TEM threshold for height is 0.60-1.30 cm and 0.24-1.61 kg for weight. Moreover coefficients of reliability above 0.95 are indicative of good quality control (Ulijaszek & Kerr, 1999). The TEM for height was 0.3 cm, and 0.1 kg for weight. The coefficient of reliability ($r = 0.98$) and the ICC ($r = 0.99$, $p < 0.05$) were above 0.95, therefore the measurement error observed

in this study was deemed acceptable for the subsequent analyses of the main study measurements to be meaningful.

Main study:

Height

Table II shows descriptive statistics for height, weight and BMI in boys, girls and the total sample and p values from inferential statistics.

****Table II here***

Height decreased in 62 of the participants (83.8%), increased in ten (13.5%), and did not change in two (2.7%), between am and pm measurements. Height decreased from am to pm measurements in the whole group ($t(73) = 8.2$, $p = 0.01$, partial eta squared = 0.5), in boys ($t(33) = 5.8$, $p = 0.01$, partial eta squared = 0.5), and in girls ($t(39) = 5.7$, $p = 0.01$, partial eta squared = 0.5).

Weight

Weight increased in 39 participants (52.7%), decreased in 29 (39.2%), and did not change in six (8.1%) between am and pm measurements. Weight did not change between morning and afternoon in the whole sample ($Z = -1.6$, $p = 0.09$) or in boys ($Z = -8.2$, $p = 0.41$) but increased in girls ($Z = -2.8$, $p = 0.01$, $r = 0.4$).

Body Mass Index

BMI increased in 60 participants (81.1%) decreased in eleven (14.9%), and did not change in three (4.1%) between the am and pm measurements. BMI increased in the

whole sample from BMI morning to BMI afternoon ($Z = -5.8, p = 0.01, r = 0.6$) and in both boys ($Z = -3.2, p = 0.01, r = 0.5$) and girls ($Z = -4.8, p = 0.01, r = 0.7$).

Body Mass Index Percentile

BMI percentile increased in 46 participants (62.2%), decreased in 7 (9.5%), and did not change in 21 participants (28.4%). Change in BMI percentile ranged from -11 to +11 centiles. BMI percentile increased in the whole sample (Mdn = 57th to 59.5th, $Z = -4.4, p = 0.01, r = 0.5$), in boys (Mdn = 45.5th to 47.0th, $Z = -2.2, p = 0.02, r = 0.3$) and in girls (Mdn = 77.0th to 78.5th, $Z = -3.9, p = 0.01, r = 0.6$).

NCMP Clinical Cut-off Body Mass Index Category (91st & 98th centile)

BMI weight classification for boys, girls, and total sample from the morning measurements (BMICATClin-am) and afternoon measurements (BMICATClin-pm) are shown in Table III. BMI weight classification between the morning measurements (BMICATClin-am) and afternoon measurements (BMICATClin-pm) did not change ($Z = -1.0, p = 0.32$) in the whole sample. Change in BMICATClin from am to pm measurements was observed in one girl. The participant moved from the *healthy weight* to the *overweight* category with a BMI increase of 0.28 kg.m², a BMI-percentile increase of 1.2 centiles, a height decrease of 0.75 cm, and a weight increase of 0.20 kg. There was no difference in the magnitude of height, weight or BMI change from am to pm measurements between BMICATClin-am groups ($H(3) = 2.8, p = 0.41$; $H(3) = 6.6, p = 0.86$; $H(3) = 2.2, p = 0.53$). The magnitude of BMI percentile change was different between BMICATClin-am groups ($H(3) = 19.3, p = 0.01$). Post hoc Mann-Whitney U tests (controlling for type I error across tests using the Bonferroni corrected alpha (0.05/3), $p \leq 0.02$) identified a difference between the *healthy weight* and *overweight*

groups ($U = 127.5$, $p = 0.01$, $r = 0.4$), and healthy weight and very overweight groups ($U = 61.0$, $p = 0.01$, $r = 0.3$) with *healthy weight* children increasing in BMI centile (Mdn diff pm-am = + 2 centiles) and both *overweight* and *very overweight* children displaying no change (Mdn diff pm-am = 0 centiles).

NCMP Population Monitoring Cut-off Body Mass Index Category (85th and 95th centile).

BMI weight classification from the morning measurements (BMICATPop-am) and afternoon measurements (BMICATPop-pm) did not change ($Z = -1.7$, $p = 0.08$) in the whole sample. BMI category change from am to pm measurements was also only observed in girls. Three of the girls (7.5%) increased BMI weight category between morning and afternoon measurements with two moving from the *healthy weight* to *overweight* category and one moving from the *overweight* to *obese* category with BMI increases of only 0.30, 0.55 and 0.26 kg.m⁻² respectively.

There was no difference in the magnitude of height, or BMI change from am to pm measurements between BMICATPop-am groups ($H(3) = 3.1$, $p = 0.38$; $H(3) = 2.9$, $p = 0.40$). The magnitude of weight change was different between BMICATPop-am groups ($H(3) = 9.4$, $p = 0.02$). Post hoc Mann-Whitney U tests (controlling for type I error across tests using the Bonferroni corrected alpha (0.05/3), $p \leq 0.02$) identified a difference between the *healthy weight* and *obese* groups ($U = 265.0$, $p = 0.02$, $r = 0.3$) with *obese* children increasing in weight, and *healthy weight* displaying no change (Mdn diff pm-am = +0.2 vs 0.0 kg). The magnitude of BMI percentile change was different between BMICATPop-am groups ($H(3) = 19.3$, $p = 0.01$). Post hoc Mann-Whitney U tests identified a difference between *healthy weight* and *obese* groups

($U = 161.0$, $p = 0.01$, $r = 0.4$), and *overweight* and *obese* groups ($U = 12.5$, $p = 0.01$, $r = 0.4$). *Healthy weight* children displayed a median increase in BMI percentile (pm-am) of 2 centiles, *overweight* an increase of 1 centiles, and *obese* no change.

****Table III here***

Discussion

As shown in table II, mean height decreased from morning to afternoon. The effect size was large, and the magnitude of diurnal variation in height observed parallels that found by Siklar et al. (2005), who reported a total diurnal height loss of -0.51 cm, and Voss & Bailey (1997) who also found a -0.51cm decrease. In the present study, boys height decreased by 0.53 cm and girls height decreased by 0.50 cm, which was comparable to the -0.47 cm for boys and -0.48 cm girls found by Siklar et al. (2005) and -0.46 cm for boys by Whitehouse et al. (1974).

Whilst no changes in weight were found for the whole sample or for boys, weight increased during the school day in the girls with the data showing a median difference of +0.10 kg (0.30 IQR). This may be an indication of greater propensity for weight variation in girls compared to boys, although the reasons for such a gender dependent increase are unknown as energy and fluid intake and energy expenditure between the morning and afternoon measurements were not assessed as part of the current study. These measurements were considered but were not included due to the possible impact this obvious ‘monitoring’ of food and activity may have had upon the children either consciously or subconsciously altering their normal school-day food and activity habits.

The additive effect of school-day variation in height and weight was reflected in the increase of BMI observed in 81% of the sample. At the group level, the effect size showed a large increase in BMI (Mdn of the increase: +0.16 kg.m², $r = 0.5$) for the whole sample, for boys (Mdn of the increase: +0.12 kg.m², $r = 0.5$) and girls (Mdn of the increase: +0.18 kg.m², $r = 0.7$). Therefore, there was a systematic increase in BMI over the school day.

The previously identified systematic group changes in actual BMI from the morning to afternoon measurements, at the individual level, resulted in one NCMP relevant BMI category change when applying the clinical cut-off's. In one girl, an increase in BMI of 0.28 kg.m² was sufficient to increase her categorisation from just within the *healthy weight* category (measured at the 90th centile) in the morning to just within the *overweight* category (measured at 91.2 centile) in the afternoon. When applying the population cut-off's, differential misclassification was magnified as three girls increased their BMI categorisation, with an increase in BMI as small as 0.26 kg.m² sufficient to alter a girl's BMI category. It appears therefore that whilst no significant changes were observed in categorisation using either cut-off's, at the individual level girls are more susceptible to differential classification when categorised using the population monitoring cut-off's.

There was also a systematic increase in BMI percentile in the whole sample (Mdn increase = 2.5 centiles) and whilst children in the *healthy weight* groups as categorised using both BMI cut-off's were significantly more susceptible to increasing BMI percentile, compared to the *overweight* and *very overweight/obese* groups respectively, this is most likely due to the presence of a greater range of available centiles within the

healthy range compared to the *overweight*, and *very overweight/obese* categories rather than any category dependent pattern of diurnal change in BMI.

Whilst the sample in the current study is limited in size, it did include all of the pupils from three primary schools all of whom had previously been included in the NCMP data from each school. As such, the sample represents the same children measured by the NCMP in 2009/10 in this district and represents similar proportions in each of the BMI categories compared with the national data. The number of children classified into each NCMP BMICATClin category from the morning and afternoon measurements in the sample used in this study (Table III) is comparable to recent nationwide NCMP data (NHS Information Centre, 2009). Further the sample size is also suitable for the analysis of reliability in anthropometric variables. The real importance of the findings generated from this sample lies in the individual level identification of differences in BMI-category classification caused by time-of-day variation.

The findings in the current study are all resultant from measurements performed by one trained researcher, using the mean of repeat measures within protocol defined accuracy limits ($\pm 4\text{cm}$, $\pm 1\text{kg}$), and undertaken with the explicit intention of measuring the child accurately in a clearly defined time period within the school day. Arguably therefore the time of day in which the measurements are performed (morning or afternoon) should be standardised as a simple procedural change to the NCMP guidelines.

Conclusion

This is the first study to examine the effect of the additive interactions between school day biological variation in height and weight upon BMI-determined weight category in Year 6 children (age 10-11 years). The summative contribution of intra-observer measurement error and biological height loss from morning to afternoon has been shown to systematically increase BMI, and BMI percentile in both boys and girls. In combination with a systematic increase in weight in the afternoon in girls, this data has illustrated that at the individual level, BMI category may potentially be classified differently and unfavourably in a small number of girls when measured in the afternoon compared to the morning.

A considerable amount of further research is required to attempt to investigate and minimise the measurement variation inherent in the NCMP data; variation that may be attributable to the use of multiple measurers who may have received limited training and who may only be taking single measurements under considerable time pressure and in often less than favourable conditions during the busy school day.

Key messages:

- Both clinical and population BMI-determined weight status categories calculated from height and weight as part of the National Child Measurement Programme may be subject to diurnal variation at the individual level, particularly in girls;
- When measured in the afternoon, children have decreased stature and in girls only greater weight, than if measured in the morning, increasing BMI and BMI percentile from morning to afternoon measurements;

- The time of day (morning or afternoon) when measurements are performed for the National Child Measurement Programme, and indeed all height and weight based public health surveillance programmes in children, requires standardisation;

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Tables

Table I. Intra-observer reliability ($n = 35$)

Reliability statistic	Height (cm)	Weight (kg)
SD of differences	0.46	0.20
Standard error	0.32	0.14
TEM	0.33	0.14
R-coefficient (r)	0.98	1.00
ICC (r)	0.99*	1.00*

*Significant at the $p= 0.05$ level.

Table II. School day variation in height, weight and body mass index.

Variable	Statistic	Boys (n =34)	Girls (n = 40)	Total (n = 74)
Morning Height (cm)	<i>Mean ± SD</i>	141.16 ± 7.45	144.58 ± 7.66	143.01 ± 7.71
	<i>95% CI</i>	(138.56 to 143.76)	(142.13 to 147.03)	(141.23 to 144.80)
	<i>Range</i>	125.55 to 163.50	126.00 to 165.50	125.55 to 165.50
Afternoon Height (cm)	<i>Mean ± SD,</i>	140.63 ± 7.34	144.08 ± 7.61	142.50 ± 7.64
	<i>95% CI</i>	(138.07 to 143.19)	(141.65 to 146.51)	(140.73 to 144.26)
	<i>Range</i>	124.95 to 161.45	125.60 to 165.35	124.95 to 165.35
Height Change (cm)	<i>Mean ±SD</i>	-0.53 ± 0.53	-0.50 ± 0.55	-0.51 ± 0.50
	<i>95% CI</i>	(-0.35 to -0.72)	(-0.32 to -0.67)	(-0.39 to -0.64)
	<i>Range</i>	-2.05 to 0.45	-2.50 to 0.75	-2.50 to 0.75
	<i>p *</i>	0.01	0.01	0.01
Morning Weight (kg)	<i>Median (IQR)</i>	32.70 (13.30)	41.40 (12.08)	36.40 (13.63)
	<i>Range</i>	26.60 to 71.70	23.70 to 75.40	23.70 to 75.40
Afternoon Weight (kg)	<i>Median (IQR)</i>	32.60 (13.40)	41.60 (12.15)	36.35 (13.54)
	<i>Range</i>	26.50 to 71.60	23.90 to 75.90	23.90 to 75.90
Weight Change (kg)	<i>Median (IQR)</i>	-0.08 (0.24)	+0.10 (0.30)	+0.07 (0.30)
	<i>Range</i>	-1.00 to 1.05	-0.45 to 0.60	-1.00 to 1.05
	<i>p*</i>	0.41ns	0.01	0.09ns
Morning BMI (kg.m ²)	<i>Median (IQR)</i>	16.76 (4.21)	19.22 (6.02)	18.04 (4.79)
	<i>Range</i>	13.54 to 34.58	13.90 to 27.86	13.54 to 34.58
Afternoon BMI (kg.m ²)	<i>Median (IQR)</i>	16.88 (4.20)	19.42 (6.43)	18.13 (5.03)
	<i>Range</i>	13.65 to 34.87	13.90 to 27.94	13.65 to 34.87
BMI Change (kg.m ²)	<i>Median (IQR)</i>	+0.12 (0.24)	+0.18 (0.17)	+ 0.16 (0.23)
	<i>Range</i>	-0.50 to 0.51	-0.27 to 0.63	-0.50 to 0.63
	<i>p*</i>	0.01	0.01	0.01

*time difference (p<0.05).

Table III. Frequency and percentage of NCMP BMI weight categories (Clinical cut-offs- 91st & 98th centile) in the morning and afternoon for boys, girls and total sample.

	Morning				Afternoon			
	Underweight	Healthy weight	Overweight	Very overweight	Underweight	Healthy weight	Overweight	Very overweight
Boys (n = 34)	1 (2.9)	25 (73.5)	6 (17.6)	2 (5.9)	1 (2.9)	25 (73.5.)	6 (17.6)	2 (5.9)
Girls (n =40)	1 (2.5)	27 (67.5)	7 (17.5)	5 (12.5)	1 (2.5)	26 (65.0)	8 (20.0)	5 (12.5)
Total (n = 74)	2 (2.7)	52 (70.2)	13 (17.6)	7 (9.5)	2 (2.7)	51 (68.9.9)	14 (18.9)	7 (9.5)