Are children living with obesity more likely to experience musculoskeletal symptoms during childhood? A linked longitudinal cohort study using primary care records

Authors

Nicola Firman[1] MSc, Health Data Scientist (0000-0001-5213-5044)*

Kate Homer[1], Senior Health Data Scientist

Gill Harper[1] PhD, Post-Doctoral Research Fellow in Health Data Science (0000-0002-3492-2076)

John Robson[1] MD, Clinical Reader in Primary Care Research & Development (0000-0001-6889-0415)

Carol Dezateux[1] MD, Professor of Clinical Epidemiology and Health Data Science (0000-0001-9787-6276)

[1]Centre for Primary Care, Wolfson Institute of Population Health, Barts and the London School of Medicine and Dentistry, Queen Mary University of London, Yvonne Carter Building, 58 Turner Street, London, E1 2AB

*Corresponding author. Nicola Firman (nicola.firman@qmul.ac.uk). Centre for Primary Care, Wolfson Institute of Population Health, Barts and the London School of Medicine and Dentistry, Queen Mary University of London, Yvonne Carter Building, 58 Turner Street, London, E1 2AB

Abstract

Objective

To assess whether there is a higher incidence of musculoskeletal consultations in general practice (GP) among children with obesity.

Design

Longitudinal

Setting

285 north-east London GPs

Participants

64,408 (50.9% boys) Reception and 56,149 (51.1% boys) Year 6 National Child Measurement Programme (NCMP) participants, linked to GP electronic health records (EHRs).

Main outcome measure

A GP consultation with a recorded musculoskeletal symptom or diagnosis.

Methods

We calculated proportions with a musculoskeletal consultation by ethnic-adjusted weight status (underweight<2nd; overweight≥91st; obese≥98th centile), sex, ethnicity, and area-level deprivation. We estimated mutually-adjusted hazard ratios (HRs) and 95% confidence intervals (CI) using Cox's Proportional regression models stratified by school year and sex.

Results

We identified 1,868 (3.0%) Reception and 4,477 (8.1%) Year 6 NCMP participants with at least one musculoskeletal consultation. In adjusted analyses, Reception year girls with a BMI classified as overweight (HR: 1.24; 95% CI: 1.02,1.52) or obese (HR: 1.67; 95%CI: 1.35,2.06) were more likely to have at least one musculoskeletal consultation. Year 6 girls with obesity were more likely (1.20; 1.07,1.35), and boys with a BMI in the underweight range (0.39; 0.21,0.73) less likely, to have a musculoskeletal consultation.

Conclusions

Girls living with obesity at the start or end of primary school are more likely to attend their GP for a musculoskeletal consultation. Routine linkage of NCMP data to EHRs provides useful insights into childhood health conditions related to excess weight in early childhood. Recognition of obesity as a contributing factor for musculoskeletal symptoms may inform clinical management, particularly in girls.

What is already known on this topic?

- Obesity is considered a contributing factor for some musculoskeletal outcomes. A recent systematic review found that children with obesity at school entry are more likely to experience back pain, slipped capital femoral epiphysis or fractures during childhood, however, the strength of this evidence is low due to the small number of eligible studies included in the review and their overall quality.

What this study adds

- We found in a large ethnically diverse population of primary school children that girls, but not boys, living with obesity are more likely to have at least one general practice consultation for a musculoskeletal symptom or diagnosis.

How this study might affect research, practice or policy

- This research adds to our understanding of associations between obesity and musculoskeletal outcomes during childhood, and has the potential to inform clinical assessment.
- These analyses demonstrate the value of linking routinely collected National Child Measurement Programme data to general practice electronic health records for research.

Introduction

Global prevalence estimates suggest one in three adults experience a chronic musculoskeletal condition with associated symptoms of pain, disability, poor mental health and a range of other comorbidities.(1-4) A United Kingdom (UK)-based primary care study found that one in every three children had a musculoskeletal problem, ranging from self-limiting conditions to serious issues with associated mortality or severe morbidity.(5)

The increasing prevalence of obesity may contribute to the overall burden of poor musculoskeletal health. Obesity increases the likelihood of some musculoskeletal outcomes,(6) particularly back pain,(7) chronic pain(8, 9) and slipped capital femoral epiphysis (SCFE).(10) The underpinning pathophysiology suggests that the excess weight carried with obesity places additional stress on the body's joints.

Paulis and co-authors' 2014 systematic review found there was evidence in support of an association between overweight and musculoskeletal pain and injuries and fractures during childhood, although the quality of evidence was considered moderate to low.(11) This review predominantly summarised cross-sectional studies, leaving the temporal relationship between exposure and outcome difficult to ascertain. Our recent systematic review of longitudinal evidence found that children with obesity at school entry are more likely to experience back pain, SCFE or fractures during childhood, but there were few eligible studies included and they were of moderate quality.(12) We noted that potential confounding variables were inconsistently accounted for in the included studies.

In this study we aim to address this gap in knowledge by investigating whether the incidence of musculoskeletal symptoms is increased during childhood among children living with obesity compared to those of healthy weight.

Methods

Study population

We included 123,836 of 128,544 (96.3%) National Child Measurement Programme (NCMP) participants from four NEL local authorities (City & Hackney, Newham, Tower Hamlets, and Waltham Forest) whose records were deterministically linked to a primary care registration, using a pseudonymised National Health Service (NHS) number created using OpenPseudonymiser software(13) (supplementary Figures S1 and S2).

Data sources

Children in the first (Reception) and last (Year 6) years of primary school are invited to participate in the NCMP, which measures the height and weight of 4-5- and 10-11-year-olds attending state-maintained schools in England. We developed data processing agreements, in line with national guidance,(14) with each of the four local authority public health departments for the sharing of NCMP data for the 2013/14-2018/19 academic years.

Pseudonymised primary care data were obtained from the Discovery Data Service (DDS) which receives coded primary care data on a daily basis for all GPs in NEL. Demographic and clinical data recorded up to 1st November 2021 were extracted for NCMP participants successfully linked to the DDS. All data were extracted and managed according to UK NHS information governance requirements.(15)

Data processing

Musculoskeletal consultations were identified as events recorded with any of the pre-specified Systemized Nomenclature of Medicine (SNOMED) clinical codes (supplementary table S1). Only the first record of a musculoskeletal consultation was retained and 5,054 children with a musculoskeletal consultation occurring before their NCMP measurement were excluded (supplementary figure S3).

Primary outcome

For each child, a binary variable was derived indicating those with or without at least one musculoskeletal GP consultation following NCMP measurement. The censor date was the date of the first musculoskeletal consultation. The censor date for children with no musculoskeletal consultation was the earliest of the date at which clinical data were extracted (31st October 2021) or the GP registration end date.

Exposure

Ethnic-specific body mass index (BMI) adjustments(16) were applied to NCMP-recorded BMI, and weight status was determined according to the UK1990 clinical reference standard(17) categorising BMI into one of four mutually exclusive groups: "underweight" (<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile) based on alignment with sex- and age-specific BMI centiles using the LMS growth tool Excel add-in.(18, 19)

Confounding factors

NCMP-recorded ethnic group was defined using the NHS classification(20) and grouped into four mutually exclusive groups: White ('White British', 'White Irish', or 'any other White background'); Black ('Black African', 'Black Caribbean', or 'any other Black background'); South Asian ('Indian', 'Pakistani', 'Bangladeshi' or 'Sri Lankan'); and a combination of Mixed and Other ('any other ethnic group', 'mixed ethnicity', 'Chinese' or 'Asian other'). Where ethnic group was missing or reported as 'not stated' in the NCMP (*n*=11,903), ethnic group most recently recorded in the EHR was used (*n*=10,785). We excluded 1,118 children with ethnic group missing in both data sources (0.9% of 126,829).

An area-level measure of relative deprivation – Index of Multiple Deprivation (IMD) score and an associated decile(21) – assigned by Public Health England to each NCMP record based on the postcode of the child's home address, was used. IMD decile was concatenated into five quintiles ranging from most to least deprived. In some instances it was necessary to combine the third to fifth least deprived quintiles to minimise the risk of disclosure of individuals.

Statistical analyses

We estimated the proportion with and without at least one musculoskeletal consultation, by sociodemographic characteristics. Follow-up time was derived as the difference in time (years) between NCMP and censor date, and incidence rates (per 1,000 person-years) with 95% confidence intervals (CI) calculated. Cumulative incidence was plotted using Kaplan-Meier failure functions by weight status. Cox's Proportional hazards regression was conducted to estimate hazard ratios (HR) and corresponding 95% CIs for a first musculoskeletal consultation, adjusting for confounding factors, academic year of participation in the NCMP and local authority of the school. We tested an interaction between sex and school year of NCMP measurement and stratified subsequent analyses. Proportional hazards assumptions were tested using a log-log plot (−ln [−ln(survival)] curves) for each category of weight status, and deemed to be met if the curves were parallel. All analyses were conducted using Stata (MP/15.0).

Patient and public involvement

This research was done without patient or public involvement. Neither were invited to comment on the study design and were not consulted to develop relevant outcomes or interpret results.

Ethics approval

The analyses of linked pseudonymised NCMP and GP data were approved by the respective data controllers under data processing agreements which allow linkage of pseudonymised NCMP data between the research organisation (Clinical Effectiveness Group, Queen Mary University of London) and each local authority public health team. This study is a secondary analysis of de-identifiable data and no further ethics approval was required.

Results

Sample characteristics

The study sample comprised 63,418 (50.9% boys) 4-5-year-olds and 55,364 (50.8% boys) 10-11-years-olds in the Reception and Year 6 cohorts respectively. The majority of children lived in the most deprived areas and were from Black or minority ethnic groups (Table 1). Fewer than 1% of children were missing ethnic background and were subsequently excluded from further analyses (*n*=1,118).

In the Reception cohort, 8.9% of boys and 7.1% of girls were living with obesity compared to 19.9% and 14.4% in the Year 6 cohort (Table 1). Among children in the Reception and Year 6 cohorts, 3.0% and 8.1% had at least one musculoskeletal consultation following NCMP measurement. Just 194 Reception and 875 Year 6 children had more than one musculoskeletal consultation following their NCMP measurement.

Do musculoskeletal consultations vary by weight status?

The proportion of the Reception cohort with a musculoskeletal consultation was higher among girls with obesity compared to girls with a healthy weight, but there were no differences among boys (Table 2). In the Year 6 cohort, a greater proportion of girls with obesity, and a smaller proportion of boys with a BMI classified as underweight, had a musculoskeletal consultation, compared with their counterparts with a healthy weight.

Which musculoskeletal symptoms and diagnoses are recorded?

The most commonly recorded musculoskeletal symptoms/diagnoses were related to the knee and back (Table 3). Among the Reception cohort with at least one musculoskeletal consultation, 45.6% of boys and 41.4% of girls reported knee pain. Among the Year 6 cohort, equivalent proportions were 40.4% and 35.8%. In the Reception cohort, 21.6% of boys and 32.1% of girls reported back pain, compared with 30.3% of boys and 44.8% of girls in the Year 6 cohort.

Does the incidence of musculoskeletal consultations vary by weight status?

Person-years of follow-up ranged from two to eight years in both cohorts. On average, the first musculoskeletal consultation occurred 2.7 (interquartile range: 1.4,4.3) and 2.1 (1.1,3.3) years after Reception and Year 6 NCMP measurements, respectively.

The incidence of at least one musculoskeletal consultation among boys and girls was 7.5 and 8.0 per 1,000 person-years in the Reception cohort, and 21.5 and 19.9 per 1,000 person-years in the Year 6 cohort (supplementary table S2). The incidence of musculoskeletal consultations was higher among girls but not boys living with obesity in the Reception and Year 6 cohorts compared to their counterparts with a healthy weight, and, in the Year 6 cohort, lower in boys with a BMI classified as underweight.

The cumulative incidence of a musculoskeletal consultation in the Reception cohort was higher in girls with obesity than in girls in other weight categories (Figure 1), but there was uncertainty around this estimate given the small sample size. Among the Year 6 cohort, the cumulative incidence was similar in all weight status groups, with the exception of boys with a BMI considered underweight, in whom it was lower than in other weight categories (Figure 1). The 95% confidence interval surrounding this estimate did not overlap with any other weight status groups despite the small sample size.

Are children living with obesity more likely to have at least one musculoskeletal consultation?

The proportional hazards assumption was met (supplementary Figure S4a-b). In multivariable Cox's Proportional hazard regression analyses including all children, an interaction term between sex and school year was statistically significant (HR: 0.87; 95% CI: 0.78,0.97; supplementary Table S3). Consequently, analyses were stratified by sex and school year. Girls with a BMI in the overweight (1.24; 1.02,1.52) or obese categories (1.67; 1.35,2.06) in the Reception cohort had an increased likelihood of at least one musculoskeletal consultation (Figure 2a, supplementary Table S4). In the Year 6 cohort, girls living with obesity were more (1.20; 1.07,1.35), and boys with a BMI classified as underweight less (0.39; 0.21,0.73), likely to have at least one musculoskeletal consultation (Figure 2b, supplementary Table S5).

Discussion

Summary of key findings

In this longitudinal study of more than 120,000 children, we examined associations between child weight status and subsequent primary care consultations for musculoskeletal symptoms and diagnoses using novel linkages between school measurement and primary care EHRs. We showed that musculoskeletal primary care consultations were more likely among girls living with obesity and less likely among boys with a BMI classified as underweight.

Strengths and limitations

This study had several strengths. We used real-world linked primary care and school measurement data for a six-year period in a geographically contiguous urban area with an ethnically diverse population, representative of the wider population in NEL. We have previously shown that school measurement data provides less biased and more accurate information about child weight status than primary care EHRs.(22) We excluded musculoskeletal consultations prior to the date of school measurement to ensure the musculoskeletal outcomes were reported after the exposure of interest. We employed statistical methods accounting for the longitudinal study design.

However, there were also some limitations. It is possible that GPs may be more likely to diagnose musculoskeletal conditions in children with obesity as compared to children living without obesity. We lacked longitudinal weight and height measurements and without complete or representative anthropometry measurements in the EHR we used the NCMP measurement date as a proxy date for the onset of obesity. We are unable to determine for how long each child had been living with obesity prior to their NCMP measurement date and as such our estimates of time to first musculoskeletal consultation are likely to be underestimates.

As most children in our study lived in the most deprived areas, we lacked statistical power to assess inequalities in musculoskeletal consultations. We only had access to an area-level measure of deprivation which may attenuate associations due to misallocating individuals to the average deprivation level of the area.(23) We lacked information about children's participation in physical activity, a potential confounder of the association between obesity and musculoskeletal health. Physical activity is known to reduce the likelihood of obesity but to increase the likelihood of musculoskeletal injuries. Musculoskeletal injuries are more likely following participation in high-impact, vigorous activities, which are more likely to be experienced by boys compared with girls.(24) Future analyses should consider the role of physical activity in confounding the relationship between obesity and musculoskeletal outcomes.

Comparison with existing literature

Our findings are similar to those of Ortiz-Pinto et al. who identified an increased incidence of musculoskeletal consultations in Spanish children with obesity.(25) They did not report sex or ethnic differences in incidence in their study.

We found that knee pain was the most common musculoskeletal symptom, although our prevalence estimates are lower than estimates from a survey completed by Finnish children.(26) Whilst there is evidence to suggest obesity during adulthood is a risk factor for knee pain,(27) less is known about this relationship in childhood. Diagnoses of Osgood-Schlatter's disease (a condition causing pain and swelling below the knee joint during periods of adolescent growth) are more common among children participating in vigorous, high-impact sport.(28, 29)

Very few children consulted for hip-related conditions so we were unable to investigate the relationship between obesity and SCFE. Given that SCFE is the most common hip disorder among adolescence,(30) this may be explained by our relatively limited period of follow-up into adolescence. Perry at al. identified an increased risk of SCFE among children with obesity.(31) Additionally, our analyses focussed on first musculoskeletal

event, which in the case of SCFE may present as knee pain.(32) Follow-up to ascertain diagnoses following initial consultations may identify more children subsequently diagnosed with SCFE.

Implications for research, policy and practice

Poor musculoskeletal health during childhood has the potential to significantly impact quality of life, throughout childhood and continuing into adolescence and adulthood.(33) Participation in some physical activities may be limited by musculoskeletal problems.(34) In turn, increased weight has the potential to contribute to continued musculoskeletal pain, and consequently children may experience a perpetual obesity/ musculoskeletal pain cycle as adolescents and adults.(34)

Our longitudinal findings have the potential to inform clinical assessment in primary care. Health care professionals, who reportedly have limited awareness of childhood onset musculoskeletal health conditions,(35) may be more aware of the potential contribution of excess weight to these conditions among primary school aged children. This is particularly important because GPs are the first point of contact for children and their families.(36)

Our study demonstrates the value of linking school measurement and primary care EHRs for research. While not designed for research purposes, EHRs are a rich source of health data, are relatively inexpensive, and potentially less biased given the near-universal nature of enrolment into general practice in the NHS.

Conclusion

Girls living with obesity are more likely to consult their GP for musculoskeletal symptoms than those with a healthy weight. Routine linkage of school measurement and primary care records enable important insights into the associations between excess weight and subsequent health in childhood and has the potential to inform clinical management. Longer term follow-up is needed to explore whether these symptoms persist.

Tables and figures

Table 1 – Sample characteristics by sex and school year of participation in the National Child Measurement Programme

	Reception cohort (*n*=63,418)						Year 6 cohort (*n*=55,364)					
	Boys (*n*=32,257)			Girls (*n*=31,161)			Boys (*n*=28,270)			Girls (*n*=27,094)		
	n	%	SD[1]	*n*	%	SD[1]	*n*	%	SD[1]	*n*	%	SD[1]
Local authority[2]												
City & Hackney	7368	22.8	0.49	7081	22.7	0.50	6259	22.1	0.52	5930	21.9	0.54
Newham	10799	33.5	0.45	10613	34.1	0.46	9793	34.6	0.48	9438	34.8	0.49
Tower Hamlets	5848	18.1	0.50	5595	18.0	0.51	5252	18.6	0.54	5118	18.9	0.55
Waltham Forest	8242	25.6	0.48	7872	25.3	0.49	6966	24.6	0.52	6608	24.4	0.53
Academic year[3]												
2013/14	2832	8.8	0.53	2821	9.1	0.54	2249	8.0	0.57	2146	7.9	0.58
2014/15	3366	10.4	0.53	3335	10.7	0.54	2779	9.8	0.56	2680	9.9	0.58
2015/16	6174	19.1	0.50	5979	19.2	0.51	5423	19.2	0.53	5005	18.5	0.55
2016/17	6804	21.1	0.49	6352	20.4	0.51	5692	20.1	0.53	5560	20.5	0.54
2017/18	6619	20.5	0.50	6511	20.9	0.50	6002	21.2	0.53	5724	21.1	0.54
2018/19	6462	20.0	0.50	6163	19.8	0.51	6125	21.7	0.53	5979	22.1	0.54
Ethnic group[4]												
White	9151	28.4	0.47	8682	27.9	0.48	6761	23.9	0.52	6478	23.9	0.53
Mixed and Other	6481	20.1	0.50	6171	19.8	0.51	5668	20.0	0.53	5425	20.0	0.54
South Asian	10425	32.3	0.46	10129	32.5	0.47	9550	33.8	0.48	9278	34.2	0.49
Black	5962	18.5	0.50	5933	19.0	0.51	5983	21.2	0.53	5587	20.6	0.54
Missing[5]	238	0.7	0.55	246	0.8	0.56	308	1.1	0.59	326	1.2	0.60
Index of Multiple Deprivation quintile[6]												
Most deprived	17423	54.0	0.38	17130	55.0	0.38	15670	55.4	0.40	15068	55.6	0.40
2	12474	38.7	0.44	11811	37.9	0.45	10652	37.7	0.47	10084	37.2	0.48
3	1921	6.0	0.54	1818	5.8	0.55	1588	5.6	0.58	1606	5.9	0.59
4	300	0.9	0.55	279	0.9	0.56	255	0.9	0.59	233	0.9	0.60
Least deprived	94	0.3	0.56	85	0.3	0.57	57	0.2	0.59	70	0.3	0.61
Missing	45	0.1	0.56	38	0.1	0.57	48	0.2	0.59	33	0.1	0.61
Weight status[7]												
Underweight	599	1.9	0.55	322	1.0	0.56	298	1.1	0.59	377	1.4	0.60
Healthy weight	25216	78.2	0.26	25315	81.2	0.25	17129	60.6	0.37	17969	66.3	0.35
Overweight	3349	10.4	0.53	3081	9.9	0.54	4895	17.3	0.54	4516	16.7	0.55
Obese	2855	8.9	0.53	2197	7.1	0.55	5639	19.9	0.53	3906	14.4	0.56
Missing	238	0.7	0.55	246	0.8	0.56	309	1.1	0.59	326	1.2	0.60
At least one musculoskeletal consultation												
No	31334	97.1	0.09	30205	96.9	0.10	25867	91.5	0.17	24970	92.2	0.17
Yes	923	2.9	0.55	956	3.1	0.56	2403	8.5	0.57	2124	7.8	0.58

[1] Standard deviation. [2] Local authority of school where child participated in the National Child Measurement Programme (NCMP). [3] Academic year of participation in the NCMP. Academic years run from September to July. [4] As recorded in the NCMP and, where missing, supplemented with ethnic group as recorded in the child's primary care electronic health record. [5] Children with missing ethnic group are excluded from subsequent analyses. [6] 2015 Index of Multiple Deprivation quintile assigned based on the child's home address postcode as recorded by the school where the child participated in the NCMP. [7] NCMP-recorded body mass index (BMI) after application of ethnic-specific BMI adjustments, categorised according to UK1990 clinical reference standard: "overweight" (≥91st to <98th centile), or "obese" (≥98th centile).

Table 2 – Distribution of those with at least one musculoskeletal consultation following National Child Measurement Programme measurement, by school year of participation and sex

	Reception (*n*=1,868)						Year 6 (*n*=4,477)					
	Boys (*n*=917)			Girls (*n*=951)			Boys (*n*=2,374)			Girls (*n*=2,103)		
	n	%	95% CI[1]	*n*	%	95% CI[1]	*n*	%	95% CI[1]	*n*	%	95% CI[1]
Ethnic group[2]												
White	238	2.6	2.3,2.9	264	3.0	2.7,3.4	562	8.3	7.7,9.0	543	8.4	7.7,9.1
Mixed and Other	181	2.8	2.4,3.2	192	3.1	2.7,3.6	497	8.8	8.1,9.5	423	7.8	7.1,8.5
South Asian	307	2.9	2.6,3.3	285	2.8	2.5,3.2	749	7.8	7.3,8.4	642	6.9	6.4,7.5
Black	191	3.2	2.8,3.7	210	3.5	3.1,4.0	566	9.5	8.7,10.2	495	8.9	8.1,9.6
Index of Multiple Deprivation quintile[3]												
1 (most deprived)	583	3.3	3.1,3.7	618	3.6	3.4,3.9	1462	9.3	9.0,9.9	1349	9.0	8.6,9.5
2	280	2.2	2.0,2.5	283	2.4	2.2,2.7	760	7.1	6.7,7.7	628	6.2	5.8,6.8
3-5 (least deprived)	51	2.2	1.7,2.9	47	2.2	1.6,2.9	151	7.9	6.9,9.4	125	6.5	5.6,7.9
Weight status[4]												
Underweight	20	3.3	2.1,5.1	11	3.4	1.9,6.1	10	3.4	1.8,6.1	28	7.4	5.2,10.5
Healthy weight	701	2.8	2.6,3.0	728	2.9	2.7,3.1	1485	8.7	8.3,9.1	1370	7.6	7.2,8.0
Overweight	102	3.0	2.5,3.7	111	3.6	3.0,4.3	399	8.2	7.4,9.0	343	7.6	6.9,8.4
Obese	94	3.3	2.7,4.0	101	4.6	3.8,5.6	480	8.5	7.8,9.3	362	9.3	8.4,10.2

[1] Confidence interval. [2] As recorded in the National Child Measurement Programme (NCMP) and, where missing, supplemented with ethnic group as recorded in the child's primary care electronic health record. [3] 2015 Index of Multiple Deprivation quintile assigned based on the child's home address postcode as recorded by the school where the child participated in the NCMP. The third, fourth and fifth least deprived quintiles were combined to minimise disclosive risk. [4] NCMP-recorded body mass index (BMI) after application of ethnic-specific BMI adjustments, categorised according to UK1990 clinical reference standard: "underweight" (<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile).

Table 3 – Distribution of first recorded musculoskeletal symptoms/diagnoses by anatomical region, stratified by school year of National Child Measurement Programme participation and sex

	Reception				Year 6			
	Boys		Girls		Boys		Girls	
	n	%	*n*	%	*n*	%	*n*	%
At least one foot consultation								
Pes planus (flat foot)	115	12.5	95	10.0	146	6.1	112	5.3
At least one knee consultation								
Osgood-Schlatter's disease (osteochondrosis), genu valgum (knock knee) or genu varum (bow leg)	47	5.1	55	5.8	378	15.9	136	6.5
Arthralgia of knee (knee joint pain)	418	45.6	394	41.4	960	40.4	753	35.8
At least one hip consultation								
Arthralgia of hip (hip joint pain), Legg-Calve-Perthes' disease or slipped capital femoral epiphysis	139	15.2	102	10.7	170	7.2	160	7.6
At least one back consultation								
Back pain	198	21.6	305	32.1	720	30.3	942	44.8

Figure 1 – Unadjusted Kaplan-Meier failure function plotted as cumulative incidence of a first musculoskeletal consultation, by weight status[1], stratified by school year of participation in the National Child Measurement Programme and sex

[1] National Child Measurement Programme-recorded body mass index (BMI) after application of ethnic-specific BMI adjustments, categorised according to UK1990 clinical reference standard: "underweight" (<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile). Graphs truncated after six years of follow-up due to small numbers.

Figure 2 – Multivariable[1] Cox proportional hazard ratios estimating the likelihood of at least one musculoskeletal consultation following National Child Measurement Programme measurement, by sex

[1] Mutually adjusting for National Child Measurement Programme (NCMP)-recorded body mass index (BMI) after application of ethnic-specific BMI adjustments, categorised according to UK1990 clinical reference standard: "underweight" (<2nd centile), "healthy weight" (≥2nd to <91st centile), "overweight" (≥91st to <98th centile) or "obese" (≥98th centile), ethnic group as recorded in the NCMP and, where missing, supplemented with ethnic group as recorded in the child's primary care electronic health record, 2015 Index of Multiple Deprivation quintile assigned based on the child's home address postcode as recorded by the school where the child participated in the NCMP, local authority of the school where the child participated in the NCMP, and academic year of participation in the NCMP. [2] Hazard ratio (95% confidence interval). Hazard ratios are plotted on a logarithmic scale.

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Contributor and guarantor information

CD and JR obtained funding for the study. NF, GH and CD conceptualised and designed the analyses. KH extracted data. NF carried out the background literature search, conducted the analyses, generated tables and figures and drafted the initial manuscript. All authors contributed to the interpretation of analyses and reviewed and revised the manuscript. All authors were involved in writing the paper and had final approval of the submitted and published manuscript. The corresponding authors attest that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. CD is the guarantor and accepts full responsibility for the conduct of the study, had access to the data, and controlled the decision to publish.

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Competing interests declaration

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Data sharing

NCMP data were accessed under data processing agreements with each of the local authorities as data controllers in line with Public Health England guidance. These agreements preclude onward sharing of data. Access to general practice data is enabled by data sharing agreements between the Discovery Data Service and general practice data controllers. The Discovery Programme Board has approved data access by the REAL Child Health programme team for research on the condition that it is not onwardly shared.

Transparency statement

The corresponding author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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