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EXTENDED REPORT

Association between childhood overweight measures and adulthood knee pain, stiffness and dysfunction: a 25-year cohort study

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ABSTRACT

Objective To describe the associations between overweight measures in childhood and knee pain, stiffness and dysfunction among adults 25 years later.

Methods Subjects broadly representative of the Australian population (n=449, aged 31–41 years, female 48%) were selected from the Australian Schools Health and Fitness Survey of 1985. Height, weight and knee injury were recorded and knee pain was assessed using the Western Ontario and McMaster Universities osteoarthritis index (WOMAC). Childhood height, weight and knee injury had been measured according to standard protocols 25 years earlier and body mass index (BMI) and percentage overweight were calculated.

Results The prevalence of knee pain was 34% and overweight in childhood and adulthood was 7% and 48%, respectively. Overall, there were no significant associations between childhood overweight measures and total WOMAC knee pain, stiffness and dysfunction scores in adulthood. However, in men, overweight in childhood was associated with adulthood WOMAC pain (relative risk (RR) 1.72, 95% CI 1.11 to 2.69) and childhood weight and BMI were associated with WOMAC stiffness and dysfunction. Childhood weight, BMI and overweight were all associated with the presence of adulthood walking knee pain in men and the whole sample. Most of these associations were independent of adult overweight measures. Subjects who were overweight in both childhood and adult life had a significant increase in the risk and prevalence of adulthood walking pain (RR=2.42, 95% CI 1.06 to 5.53).

Conclusions Childhood overweight measures were significantly associated with adulthood knee mechanical joint pain, stiffness and dysfunction among men, independent of adult overweight, suggesting that childhood overweight may lead to later knee symptoms in men.

INTRODUCTION

Obesity is a major public health problem among adults and, more recently, among children around the world. The rise in obesity has contributed to an epidemic of non-communicable diseases such as type 2 diabetes, hypertension and coronary heart disease. Obesity has also been strongly associated with musculoskeletal conditions, especially osteoarthritis (OA).[1]

Childhood overweight is important because it predicts adult obesity.[2] Adolescents who were overweight were almost 18 times more likely than their leaner peers to be obese in early adulthood.[3] We have also found that obesity in childhood was strongly predictive of obesity in early adulthood.[4] However, childhood obesity also affects childhood health. There is evidence for a higher prevalence of lower extremity malalignment, fractures and musculoskeletal pain among obese children than among normal weight children.[5]

The knee joint is commonly affected by pain in both overweight paediatric[5] and adult populations.[6] Up to half of people aged ≥50 years reported having knee pain during 1 year and a quarter reported having severe, disabling knee pain.[7] Studies in adults have established a link between obesity and the subsequent development or progression of knee pain.[7 8] Most of these studies were conducted in older populations. Only one study has reported a deleterious association of childhood weight with adulthood knee pain and in this study the classification of childhood obesity was based on adulthood body mass index (BMI) and a validated knee pain questionnaire was not used.[9] Therefore, we hypothesised that childhood overweight measures were associated with increased adulthood knee pain. The aim of our study was, therefore, to describe the associations between overweight measures in childhood and knee pain, stiffness and dysfunction among adults 25 years later.

MATERIALS AND METHODS

Subjects

The Childhood Determinants of Adult Health (CDAH) knee study was conducted during 2008–2010. It was a follow-up study on a subsample (n=449, aged 31–41 years, female 47.9%) of participants who completed the CDAH study during 2004–2006. The CDAH study was a 20-year follow-up (n=2410, mean age 31) of children who participated in the Australian Schools Health and Fitness Survey (ASHFS) conducted in 1985. This survey was completed on a nationwide sample of school children in the age group 7–15 years (n=8498, mean age 11), and a wide range of health-related measures were collected. The CDAH participants (n=764) residing in metropolitan Melbourne and Sydney were invited to take part in the study by letter. Subjects who agreed to participate (n=529, response percentage: 69%) were assessed for their eligibility. Exclusion criteria for this study included being pregnant, having had diseases that might affect knee cartilage, such as rheumatoid arthritis and having contraindications

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for MRI. Eighty subjects were excluded either because of the exclusion criteria, because they were pregnant by the time of interview or because they changed their mind. The remaining 449 subjects were asked to complete a computer-assisted telephone interview (CATI). A flow chart of the selection of subjects for this study is shown in figure 1. This study was approved by the Southern Tasmania Health and Medical Human Research Ethics Committee, the Monash University Human Research Ethics Committee and the Northern Sydney and Central Coast Area Human Research Ethics Committee and all participants provided written informed consent.

Anthropometric measurements

Weight was measured to the nearest 0.5 kg in 1985 and 0.1 kg at follow-up with shoes, socks and bulky clothing removed. Height was measured to the nearest 0.1 cm (with shoes and socks removed) using a stadiometer. BMI was calculated as kilograms of weight per square metre of height for both time points. Overweight in childhood was defined according to age- and sex-specific cut-off points.[10] Adulthood overweight was defined as a BMI >25 kg/m^2. Change in overweight status was categorised according to overweight status at both time points: normal in childhood and adulthood, normal in childhood and overweight in adulthood, overweight in childhood and normal in adulthood and overweight at both time points.

Knee symptom measurements

Information on knee pain and injury were collected during the CATI. We used the Western Ontario MacMaster Universities osteoarthritis index (WOMAC) for assessing knee pain, stiffness and physical dysfunction during the past 30 days on a scale of 0–9, where 0 indicated no complaints and 9 indicated the maximum intensity of the complaint. The WOMAC is an established scale for OA research and is also validated for responsiveness of knee complaints in young population without OA.[11] WOMAC knee pain was reported in five subscales: pain experienced when walking on level surface, going up and/or down stairs, sitting/lying, rest at night and standing upright. WOMAC stiffness and dysfunction were reported in 2 and 17 subscales, respectively. Total WOMAC scores were calculated by adding the scores of each subscale. Presence of any pain, stiffness and dysfunction was defined as any score >0. History of knee injury during childhood and adulthood were also recorded separately during the CATI in response to the question “Have you had a knee injury requiring non-weight-bearing treatment for more than 24 h or surgery?”

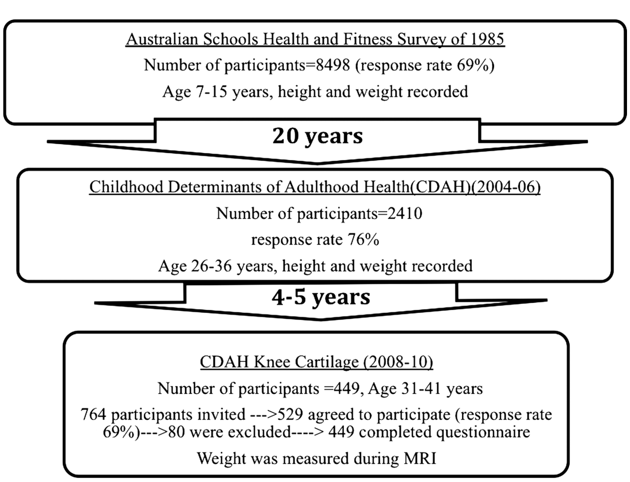

Figure 1 Flowchart showing selection of the subjects for this study from previous studies.

Statistical analyses

Our primary objective was to describe the association of childhood overweight with adulthood total WOMAC knee pain scale. We performed further exploratory analyses with the WOMAC knee pain subscale scores, particularly walking knee pain since it was the most biologically plausible subscale associated with obesity. We also analysed the associations between childhood overweight and adulthood stiffness and dysfunction. These associations were tested using childhood weight and BMI as continuous measures and overweight (yes/no) as a categorical variable. Unpaired t tests or χ^2 tests were used to assess the difference between groups based on the presence or absence of total WOMAC knee pain. Univariable and multivariable log binomial regression was used to estimate relative risk (RR) for associations between childhood overweight measures and adult knee pain, stiffness and dysfunction before and after adjustment for potential confounders. If the log binomial model failed to converge, RR was estimated using a Poisson distribution and robust SEs.[12] Age at childhood, duration of follow-up, height (if weight was the predictor), smoking status, socioeconomic status (based on the category of occupation for the longest period) and knee injury at childhood and adulthood were examined as potential confounders based on the significant associations with childhood overweight measures or knee pain and our previous findings that these are important covariates. The independent associations of each childhood overweight measures were assessed by further adjustment for the corresponding adulthood obesity measure. Interactions between sex and overweight measures on knee pain, stiffness or dysfunction were investigated by regressing knee pain, stiffness and dysfunction on a binary (0/1) term for sex within a covariate and assessed by testing the statistical significance of the coefficient of a (sex×covariate score). We decided to separate men and women for analysis owing to the distinct gender differences in our results. All statistical analyses were performed using SPSS V.19 for Mac (SPSS Inc, Chicago, Illinois, USA).

RESULTS

Characteristics of the subjects

A sample of 449 subjects was included in this analysis. The overall prevalence of total WOMAC knee pain was 34% (range 0–31, mean 1.76). Prevalence of knee pain when walking on a level surface was 10% and prevalence of overweight in childhood and adulthood was 7% and 48%, respectively, in this cohort. The prevalence of total WOMAC stiffness (range 0–17, mean 1.16) and dysfunction (range 0–125, mean 4.25) was 33% and 41%, respectively. The sample we derived for this study was representative of the original cohort and there were no significant differences between these participants, the rest of the total ASHFS sample and the CDAH sample for age, sex, BMI and overweight status (data not shown). Demographic and study factors of the participants based on whether they experienced any knee pain (split by gender) are presented in table 1. There were no significant differences in age (childhood and adulthood), childhood knee injury, BMI and weight between those with WOMAC pain and without pain. However, the proportions of childhood overweight and adulthood injury were greater for male subjects with any knee pain.

Table 1 Characteristics of the participants based on whether they experienced knee pain (total WOMAC pain >0)

	No pain	Pain	p Value
Total	(n=295)	(n=154)	
Childhood age	11.2 (2.6)	11.0 (2.6)	0.468
Childhood BMI	18.2 (2.6)	18.1 (2.6)	0.631
Childhood weight	40.8 (13.0)	40.0 (13.1)	0.517
Childhood overweight (%)	6	9	0.127*
Adulthood BMI	25.1 (3.8)	25.5 (4.3)	0.268
Sex (female, %)	48	48	0.519*
Childhood injury (%)	8	10	0.306*
Adulthood injury (%)	15	25	0.007*
Women	(n=141)	(n=74)	
Childhood age	10.9 (2.7)	11.1 (2.5)	0.660
Childhood BMI	18.2 (2.6)	18.1 (2.6)	0.658
Childhood weight	39.4 (11.6)	39.2 (11.5)	0.891
Childhood overweight (%)	7	5	0.447*
Adulthood BMI	24.2 (3.8)	24.8 (5.0)	0.370
Childhood injury (%)	3	8	0.133*
Adulthood injury (%)	11	16	0.212*
Men	(n=154)	(n=80)	
Childhood age	11.4 (2.5)	10.9 (2.7)	0.149
Childhood BMI	18.2 (2.6)	18.1 (2.6)	0.810
Childhood weight	42.1 (14.1)	40.7 (14.5)	0.478
Childhood overweight (%)	4	12	0.028*
Adulthood BMI	25.8 (3.6)	26.2 (3.5)	0.437
Childhood injury (%)	13	12	0.546*
Adulthood injury (%)	19	34	0.009*

Results are mean (SD) except for percentages.
*χ^2 Tests and t tests for others.
BMI, body mass index; WOMAC, Western Ontario and McMaster Universities osteoarthritis index.

Childhood overweight measures and adult WOMAC knee pain

Analyses using total WOMAC knee pain score (yes/no) as the outcome (table 2) showed no significant association between childhood overweight measures and total knee pain. However, sex-specific analysis showed an effect of being overweight in childhood on adult total WOMAC pain for men but not for women. This association persisted after further adjustment for adulthood overweight status.

When considering type of pain, childhood overweight measures including weight, BMI and being overweight (yes/no) were significantly and positively associated with knee pain when walking in adulthood after adjustment for covariates (all $p<0.05$) (table 3). This association was independent of the adulthood overweight measures and was stronger and only significant for men.

Childhood overweight measures and adult total WOMAC knee stiffness

Similar to total WOMAC knee pain, childhood BMI and weight were significantly and positively associated with the presence of adult total WOMAC knee stiffness in multivariable analysis for men (but not for women) after adjustment for covariates (all $p<0.05$) (table 4). These associations remained unchanged after further adjustment for the corresponding current overweight measures.

Childhood overweight measures and total WOMAC physical dysfunction

Childhood overweight measures were not associated with adult total WOMAC dysfunction in the sample overall and for women (table 5). However, among men, all childhood overweight measures were positively associated with total knee dysfunction after adjustment for covariates. All these associations, except the association of childhood weight, weakened but persisted after further adjustment for the corresponding adulthood overweight measures.

Change in overweight status from childhood to adulthood and walking WOMAC pain

Change in overweight status was significantly associated with adult knee pain when walking, for subjects who were overweight in both childhood and adult life (5%) having the greatest proportion and risk of knee pain (27.3% having knee pain, RR=2.42, 95% CI 1.06 to 5.53) compared with those who had normal weight in both childhood and adult life (51%, 8.6% having knee pain) (figure 2A). Also, subjects who were overweight in

Table 2 Association of childhood overweight measures with total WOMAC knee pain score in adulthood

	Univariable RR (95% CI)	Multivariable* RR (95% CI)	Multivariable† RR (95% CI)
Total			
BMI (per kg/m^2)	1.00 (0.98 to 1.03)	1.00 (0.94 to 1.06)	0.99 (0.92 to 1.06)
Overweight (yes vs no)	1.38 (0.92 to 2.07)	1.25 (0.82 to 1.91)	1.22 (0.79 to 1.88)
Weight (per kg)	1.00 (1.00 to 1.01)	1.00 (0.98 to 1.03)	1.00 (0.97 to 1.03)
Women			
BMI (per kg/m^2)	0.99 (0.92 to 1.07)	0.97 (0.89 to 1.06)	0.95 (0.86 to 1.05)
Overweight (yes vs no)	0.86 (0.37 to 1.99)	0.80 (0.33 to 1.95)	0.79 (0.32 to 1.95)
Weight (per kg)	1.00 (0.98 to 1.02)	0.99 (0.95 to 1.03)	0.99 (0.94 to 1.03)
Men			
BMI (per kg/m^2)	0.99 (0.92 to 1.06)	1.05 (0.96 to 1.14)	1.04 (0.94 to 1.14)
Overweight (yes vs no)	**1.82 (1.17 to 2.84)**	**1.72 (1.11 to 2.69)**	**1.68 (1.06 to 2.65)**
Weight (per kg)	1.00 (0.98 to 1.01)	1.02 (0.98 to 1.05)	1.02 (0.98 to 1.05)

Bold denotes statistical significance.B
*Adjusted for age, sex, height (for weight), duration of follow-up, child and adult knee injury, smoking status, socioeconomic position.
†Further adjusted for adult corresponding measure.
BMI, body mass index; RR, relative risk; WOMAC, Western Ontario and McMaster Universities osteoarthritis index.

Table 3 Association of childhood overweight measures with WOMAC knee pain when walking on a flat surface in adulthood

	Univariable RR (95% CI)	Multivariable* RR (95% CI)	Multivariable† RR (95% CI)
Total			
Overweight (yes vs no)	**2.92 (1.50 to 5.69)**	**2.64 (1.29 to 5.40)**	**2.68 (1.29 to 5.60)**
BMI (per kg/m^2)	**1.11 (1.02, to 1.20)**	**1.13 (1.02, to 1.26)**	**1.13 (1.00 to 1.26)**
Weight (per kg)	1.01 (0.99 to 1.03)	**1.04 (1.00 to 1.09)**	**1.04 (1.00 to 1.09)**
Women			
BMI (per kg/m^2)	1.09 (0.96 to 1.23)	1.09 (0.94 to 1.27)	1.03 (0.86 to 1.22)
Overweight (yes vs no)	1.70 (0.44 to 6.58)	1.38 (0.33 to 5.80)	1.28 (0.30 to 5.48)
Weight (per kg)	1.01 (0.98 to 1.04)	1.03 (0.96 to 1.10)	1.01 (0.93 to 1.09)
Men			
BMI (per kg/m^2)	**1.12 (1.01 to 1.25)**	**1.17 (1.01 to 1.35)**	**1.34 (1.13 to 1.58)**
Overweight (yes vs no)	**3.83 (1.78 to 8.25)**	**3.65 (1.60 to 8.33)**	**4.29 (1.83 to 10.02)**
Weight (per kg)	1.01 (0.98 to 1.03)	**1.06 (1.00 to 1.12)**	**1.08 (1.02 to 1.15)**

Bold denotes statistical significance.
*Adjusted for age, sex, height (for weight), duration of follow-up, child and adult knee injury, smoking status, socioeconomic position.
†Further adjusted for adult corresponding measure.
BMI, body mass index; RR, relative risk, WOMAC, Western Ontario and McMaster Universities osteoarthritis index.

childhood and then of normal weight in adulthood (2%) also had higher prevalence (25%) and risk (RR=1.92, 95% CI 0.46 to 8.03) of knee pain compared with subjects who were normal in childhood and became overweight in adulthood (43%, 9.8% having knee pain). A similar trend was seen when we looked at the change in overweight with total WOMAC pain (figure 2B).

DISCUSSION

This is the first long-term cohort study, to our knowledge, to study the associations between childhood overweight measures and knee pain, stiffness and dysfunction in adults. Overall, there were no significant associations between childhood overweight measures and total WOMAC knee pain, stiffness and dysfunction scores. However, childhood overweight measures were associated with knee pain (mainly pain when walking on the flat surface), stiffness and dysfunction among men. Crucially most of the associations were shown for the continuous measure of weight and BMI as well as the categorical measures of overweight. They remained unchanged after adjustment for the corresponding adult overweight measure, suggesting that childhood overweight measures can independently affect adult knee joint symptoms in men.

Our findings that childhood overweight measures predict adult knee pain when walking at a mean age of 35 is supported by a similar study that looked at the effect of BMI at 7, 11, 16, 23, 33 and 45 years on knee pain at 45 years. They found a higher risk of adulthood knee pain for the obese category in comparison with those who were underweight in each age group. Childhood BMI was associated with adult knee pain, but this association was dependent on adulthood BMI; however, BMI in the early 20s was an independent predictor of knee pain at 45 years.[9] This study had some limitations because adult BMI categories were used for the definition of overweight and obesity in childhood, the reference category for comparison was an underweight group rather than a normal weight group, men and women were not separated for analyses and they did not use a validated scale for knee pain assessment.

The mechanisms underlying the associations between childhood overweight measures and adult walking knee pain are unclear. Forces transmitted through the knee joint during

Table 4 Association of childhood overweight measures with total WOMAC knee stiffness in adulthood

	Univariable RR (95% CI)	Multivariable* RR (95% CI)	Multivariable† RR (95% CI)
Total			
BMI (per kg/m^2)	1.03 (0.98 to 1.09)	1.06 (1.00 to 1.12)	1.02 (0.96 to 1.09)
Overweight (yes vs no)	1.01 (0.60 to 1.72)	0.96 (0.57 to 1.60)	0.88 (0.52 to 1.48)
Weight (per kg)	1.00 (0.99 to 1.01)	1.02 (1.00 to 1.04)	1.01 (0.99 to 1.04)
Women			
BMI (per kg/m^2)	0.99 (0.90 to 1.08)	0.98 (0.88 to 1.09)	0.93 (0.81 to 1.05)
Overweight (yes vs no)	0.55 (0.15 to 1.99)	0.50 (0.13 to 2.01)	0.47 (0.11 to 1.96)
Weight (per kg)	1.00 (0.98 to 1.02)	0.98 (0.93 to 1.03)	0.97 (0.92 to 1.02)
Men			
BMI (per kg/m^2)	**1.06 (1.01 to 1.12)**	**1.11 (1.05 to 1.19)**	**1.10 (1.02 to 1.18)**
Overweight (yes vs no)	1.28 (0.75 to 2.18)	1.20 (0.71 to 2.05)	1.10 (0.65 to 1.89)
Weight (per kg)	1.00 (0.99 to 1.01)	**1.04 (1.01 to 1.07)**	**1.03 (1.01 to 1.06)**

Bold denotes statistical significance.
*Adjusted for age, sex, height (for weight), duration of follow-up, child and adult knee injury, smoking status, socioeconomic position.
†Further adjusted for adult corresponding measure.
BMI, body mass index; RR, relative risk, WOMAC, Western Ontario and McMaster Universities osteoarthritis index.

Table 5 Association of childhood overweight measures with total WOMAC physical dysfunction in adults

	Univariable RR (95% CI)	Multivariable* RR (95% CI)	Multivariable† RR (95% CI)
Total			
BMI (per kg/m^2)	1.02 (0.98 to 1.07)	1.04 (0.99 to 1.09)	1.02 (0.96 to 1.08)
Overweight (yes vs no)	**1.42 (1.02 to 2.00)**	1.34 (0.95 to 1.90)	1.29 (0.90 to 1.83)
Weight (per kg)	1.00 (0.99 to 1.01)	1.02 (0.99 to 1.04)	1.01 (0.99 to 1.03)
Women			
BMI (per kg/m^2)	0.99 (0.92 to 1.05)	0.98 (0.91 to 1.06)	0.95 (0.87 to 1.04)
Overweight (yes vs no)	1.11 (0.60 to 2.04)	1.01 (0.55 to 1.87)	1.00 (0.54 to 1.86)
Weight (per kg)	0.99 (0.98 to 1.01)	0.99 (0.96 to 1.03)	0.99 (0.95 to 1.02)
Men			
BMI (per kg/m^2)	1.05 (1.00 to 1.11)	**1.10 (1.03 to 1.17)**	**1.08 (1.00 to 1.16)**
Overweight (yes vs no)	**1.70 (1.15 to 2.51)**	**1.61 (1.07 to 2.43)**	**1.52 (0.99 to 2.32)**
Weight (per kg)	1.01 (0.99 to 1.02)	**1.03 (1.00 to 1.06)**	1.02 (1.00 to 1.05)

Bold denotes statistical significance.
*Adjusted for age, sex, height (for weight), duration of follow-up, child and adult knee injury, smoking status, socioeconomic position.
†Further adjusted for adult corresponding measure.
BMI, body mass index; RR, relative risk, WOMAC, Western Ontario and McMaster Universities osteoarthritis index.

walking can exceed four times body weight.[13] Consequently, increases in body weight, without associated compensatory adaptations in knee joint anatomy and limb kinematics and kinetics during movement, would increase the stresses and strains in the knee joint during walking.[14] It has been reported that each pound of weight loss will result in a fourfold reduction in the load exerted on the knee per step during daily activities, and the authors of that study suggested that a load reduction of this magnitude appeared to be clinically meaningful if accumulated over thousands of steps a day.[15] Therefore, the

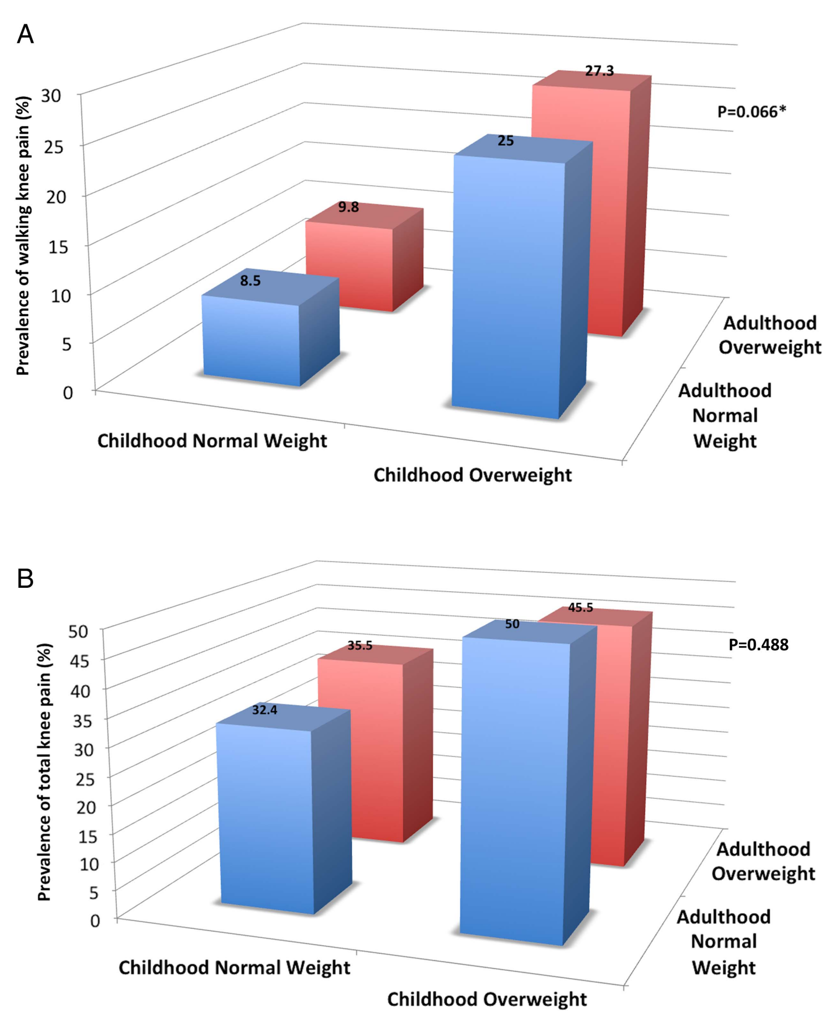

Figure 2 (A) Prevalence of adult knee pain when walking for subjects classified by their change in overweight status from childhood to adulthood (p value is from log likelihood ratio test). (B) Prevalence of adult total WOMAC knee pain for subjects classified by their change in overweight status from childhood to adulthood (p value is from log likelihood ratio test).

effects of childhood overweight on adult knee pain are probably due to increase in joint loading and alterations in gait mechanics.[16 17]

Some prospective studies in older populations have reported similar associations between BMI and total WOMAC pain, as we found for men. Jinks *et al*[18] reported that among responders with no knee pain at baseline, being obese rather than of normal weight predicted onset of severe knee pain over 3 years. Obesity was also a strong predictor of progression of knee pain, and reduction in BMI category from obese to overweight avoided 19% of new cases of severe knee pain over a 3-year period,[8] including almost half of the new cases that arose in the obese group.[18] In a retrospective study exploring the effects of weight loss in women, a loss of about 5.1 kg decreased the odds of developing symptomatic knee OA by 50% over 12 years.[19] Similarly, cross-sectional studies in children and adolescents of mean age 12.3 and 17 years found a significant increase in the odds of knee pain with every unit increase in BMI.[20 21]

The male–female differences in the results were consistent in this study, but unexpected. The adult data indicate that body fat is similarly related to pain for both men and women, suggesting that this association may be specific to childhood. The reasons for these sex discrepancies are unknown. The prevalence of OA in most joints is higher among men than among women before 50 years of age, but higher among women than among men after 50 years of age.[22 23] Consistently, the incidence of symptomatic knee OA has been found to be higher among men for all age groups before 50 years of age.[23] This is important in the context of our sample with a mean age of 35 years, in which the significant results were found only among men. In a related study we also found that BMI as a child was related to bone mass in later life among men but not women,[24] and women who were overweight in childhood had 5% greater trabecular density with no difference in cortical density. In contrast, trabecular density in men who were overweight in childhood was not different but their cortical density was 1% lower,[25] suggesting the effect of overweight in childhood is modified by sex.

The prevalence of overweight in childhood was very low as expected from a study conducted in 1985, but overweight in adulthood was much more common. Change in overweight status from childhood to adulthood was associated with increased risks of type 2 diabetes and hypertension in adults[26] and change in weight was associated with change in knee pain in adults; therefore, we hypothesised that change in overweight status would be associated with knee pain in adults. Indeed, we found that subjects who were overweight in both childhood and adult life had a greater prevalence of adult knee pain when walking (27.3% of these subjects) than those of normal weight in both childhood and adult life (8.6% of these subjects). It was interesting to note that the subjects who were overweight in childhood and then of normal weight in adulthood had substantially greater prevalence of knee pain (25% of these subjects) than did subjects who were normal in childhood and then became overweight in adulthood (9.8% of these subjects). This suggests that childhood overweight may be at least as important as adult overweight. However, these results needs to be interpreted cautiously as only 7% of the childhood cohort was overweight and few subjects (n=8) changed their weight status from overweight in childhood to normal weight in adulthood. The underlying mechanism explaining why risk is maintained when changing from overweight in childhood to normal weight in adults is unknown.

The strength of our study was the use of 25-year prospective data with detailed questionnaires on knee pain (WOMAC scale). A potential limitation of this study is that the response rate in this substudy was moderate (69% and 59% included in the study). Reassuringly, there were no significant differences in age, sex and BMI between those with and without knee pain measurements in adulthood and between subjects included in this study and the remainder of the ASHFS cohort, which reduces the possibility of selection bias. The prevalence of pain in this cohort was somewhat higher than in other population cohorts. This might be due to the use of an elaborate questionnaire like WOMAC, which is more sensitive than general questions about knee pain used in other studies, and we defined knee pain, stiffness and dysfunction using any WOMAC score of >0. We used weight as a predictor in this study, but weight itself may not represent overweight status in childhood. However, we adjusted for height to get the best estimate of fatness. Other studies used weight as an overweight measure in childhood and reported that it was associated with increased risks for later adult-onset cancers.[27] A combination of being overweight in childhood and overweight in adulthood may simply be identifying a more severely obese population of adults; however, we also found that the continuous measures of BMI and weight in childhood were significantly associated with adult knee pain when walking, stiffness and dysfunction in men, suggesting that the associations with childhood overweight would not be overestimated.

CONCLUSION

Childhood overweight measures were significantly associated with adulthood knee mechanical joint pain, stiffness and physical dysfunction among men, and were independent of the adult overweight measures. Similarly, the change in overweight status from childhood to adulthood was also associated with knee pain, with subjects who were overweight in both childhood and adult life having the greatest prevalence and risk of knee pain. These data indicate that childhood obesity may lead to later adulthood knee symptoms, especially in men.

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Contributors BA had full access to all the data in the study and takes responsibility for its integrity and the accuracy of the data analysis. Study design: CD, GJ, AV, FC, TD and LM; acquisition of data: CD, GJ, AV, FC, TD, MC and LM; analysis and interpretation of data: BA, CD, AV, LB and GJ; manuscript preparation: BA, CD, AV, LB, FC, TD, LM, MC and GJ; statistical analysis: BA, CD, LB and GJ.

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Competing interests CD is a recipient of an Australian Research Council Future Fellowship, GJ is a recipient of a National Health and Medical Research Council (NHMRC) Practitioner Fellowship, AV is a recipient of a NHMRC Senior Research Fellowship and LB is a recipient of a NHMRC Career Development Fellowship.

Patient consent Obtained.

Ethics approval Southern Tasmania Health and Medical Human Research Ethics Committee, the Monash University Human Research Ethics Committee and the Northern Sydney and Central Coast Area Human Research Ethics Committee.

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Notes