

**Is waist circumference a better predictor of incident symptomatic radiographic knee osteoarthritis, radiographic knee osteoarthritis and knee pain than body mass index over 10 years?**

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Purpose

The current obesity epidemic is leading to a rise in non-communicable diseases (NCDs) such as diabetes, hypertension, cardio-vascular diseases (CVD), cancer and musculoskeletal conditions like osteoarthritis (OA). Although body mass index (BMI) is the most useful population-level measure of obesity, it does not account for body composition or fat distribution, which is better detected with waist circumference (WC) measurement. A large WC indicates an android fat distribution with greater amounts of fat tissue around the trunk and abdomen, known as central obesity or 'apple shape' being directly linked to increases in CVD. Whether this is associated with increases in symptomatic radiographic knee osteoarthritis (SRKOA), radiographic knee osteoarthritis (RKOA) and knee pain incidence is not clear. These longitudinal associations were examined and the predictive value of using WC over BMI measurements was explored.

Methods

In 1989, 1003 middle aged women from a UK general practice were recruited to the Chingford Women's Cohort. BMI and WC were measured at the year 1 (Y1) baseline visit. The primary outcome variable at year 10 (Y10) was SRKOA, with RKOA and knee pain as secondary outcomes. SRKOA was classified positive in Kellgren and Lawrence (K&L) grade 2 or above knees reporting  $\geq 15$  days of knee pain in the last month. RKOA was classified positive in knees with K&L grade 2 or above. Knee pain was classified positive if reported in the last month for  $\geq 15$  days. All remaining knees were classified negative for each outcome. These outcomes were categorised as none, unilateral, bilateral or any (unilateral or bilateral) for analyses.

Women with total knee replacements by Y10 (n=6) were included and re-coded positive for all outcomes if not already coded so. Analyses were adjusted for age and presence of knee injury at Y1.

Logistic regression analyses were performed and expressed as odds ratios (ORs) with 95% confidence intervals (CIs) for crude and adjusted models. Pseudo  $R^2$  was provided to allow for comparison, since different units of measurement,  $\text{kg/m}^2$  for BMI and cm for WC, make direct comparisons based on effect sizes difficult to justify. BMI and WC were examined separately (table 1) and then combined in a second model and presented graphically for the primary SRKOA outcome (figure 1).

Results

A total of 646 women were included with Y1 median (IQR) age of 53 (48, 58), mean ( $\pm$ SD) BMI 25.4 (4.1), and a mean ( $\pm$ SD) WC 77.3 (9.6). At Y1, 6% had SRKOA, 13% had RKOA and 23% had knee pain.

Incident cases of all three outcomes were established by removing Y1 positive cases. By Y10 incidence of SRKOA was 6%, RKOA was 27% and knee pain was 12%.

Table 1 shows similar predictive associations between univariate Y1 BMI and WC across all three Y10 outcomes. Predictive associations were strongest for RKOA incidence, weak for SRKOA and weakest for knee pain, suggesting this association may be driven by structure.

Figure 1 shows no further value was added to the SRKOA predictive model when BMI and WC were combined, therefore use of one measurement was sufficient.

### Conclusion

BMI is the suggested measure of choice as it remained a stronger predictor than WC although associations were attenuated with unilateral, bilateral and any SRKOA. WC could be used as an alternative measurement to predict outcome if measuring BMI was difficult clinically, however there is no point in measuring both.

Associations with BMI and WC were greatest for bilateral over unilateral but only for RKOA outcome which may suggest alternative pathological mechanisms exist for structural OA compared to SRKOA and knee pain.

Table 1: Longitudinal associations between Y1 BMI & WC with Y10 SRKOA, RKOA & knee pain incidence

Where BMI=body mass index; RKOA=radiographic knee osteoarthritis; SRKOA=symptomatic radiographic knee osteoarthritis; WC=waist circumference; <sup>a</sup> adjusted for Y1 age and knee injury.

Y10 outcome (n=646) Y1 exposure		Y10 knee pain incidence (n=498)			Y10 RKOA incidence (n=563)			Y10 SRKOA incidence (n=609)		
		+	-	Pseudo R <sup>2</sup>	+	-	Pseudo R <sup>2</sup>	+	-	Pseudo R <sup>2</sup>
		(n=58) OR (95% CI) (n)	(n=440) P value		(n=154) OR (95% CI) (n)	(n=409) P value		(n=34) OR (95% CI) (n)	(n=575) P value	
Y1 BMI	Unilateral v none	n=20	n=440		n=96	n=409		n=21	n=575	
	Crude	1.00 (0.90,1.12) (n=460)	0.93	0.00	1.05 (0.98,1.11) (n=505)	0.15	0.00	<b>1.13 (1.04,1.23)</b> (n=596)	<b>0.006</b>	0.04
	Adjusted <sup>a</sup>	1.01 (0.90,1.13) (n=452)	0.84	0.00	1.04 (0.97,1.10) (n=499)	0.26	0.03	<b>1.12 (1.02,1.22)</b> (n=587)	<b>0.01</b>	0.06
	Bilateral v none	n=38	n=440		n=58	n=409		n=13	n=575	
	Crude	<b>1.07 (1.00,1.15)</b> (n=478)	<b>0.05</b>	0.01	<b>1.21 (1.14,1.30)</b> (n=467)	<b>&lt;0.001</b>	0.11	<b>1.12 (1.01,1.24)</b> (n=588)	<b>0.03</b>	0.03
	Adjusted <sup>a</sup>	<b>1.07 (1.00,1.15)</b> (n=469)	<b>0.05</b>	0.01	<b>1.20 (1.12,1.28)</b> (n=459)	<b>&lt;0.001</b>	0.13	<b>1.11 (1.00,1.24)</b> (n=578)	<b>0.05</b>	0.04
Y1 WC	Any v none	n=58	n=440		n=154	n=409		n=34	n=575	
	Crude	1.05 (0.99,1.12) (n=498)	0.10	0.01	<b>1.12 (1.07,1.17)</b> (n=563)	<b>&lt;0.001</b>	0.03	<b>1.13 (1.05,1.21)</b> (n=609)	<b>0.001</b>	0.04
	Adjusted <sup>a</sup>	1.05 (0.99,1.12) (n=489)	0.10	0.01	<b>1.11 (1.05,1.16)</b> (n=554)	<b>&lt;0.001</b>	0.06	<b>1.12 (1.04,1.20)</b> (n=599)	<b>0.002</b>	0.06
	Unilateral v none	n=20	n=440		n=96	n=409		n=21	n=575	
	Crude	1.01 (0.96,1.05) (n=460)	0.79	0.00	1.02 (0.99,1.04) (n=505)	0.17	0.00	<b>1.05 (1.01,1.09)</b> (n=596)	<b>0.01</b>	0.03
	Adjusted <sup>a</sup>	1.01 (0.96,1.06) (n=452)	0.72	0.00	1.01 (0.98,1.04) (n=499)	0.47	0.02	<b>1.05 (1.00,1.09)</b> (n=587)	<b>0.03</b>	0.06
Y1 WC	Bilateral v none	n=38	n=440		n=58	n=409		n=13	n=575	
	Crude	<b>1.03 (1.00,1.07)</b> (n=478)	<b>0.03</b>	0.02	<b>1.08 (1.05,1.11)</b> (n=467)	<b>&lt;0.001</b>	0.09	<b>1.05 (1.00,1.10)</b> (n=588)	<b>0.04</b>	0.03
	Adjusted <sup>a</sup>	<b>1.04 (1.00,1.07)</b> (n=469)	<b>0.03</b>	0.02	<b>1.07 (1.04,1.10)</b> (n=459)	<b>&lt;0.001</b>	0.11	1.05 (1.00,1.10) (n=578)	0.06	0.04
	Any v none	n=58	n=440		n=154	n=409		n=34	n=575	
	Crude	<b>1.03 (1.00,1.05)</b> (n=498)	<b>0.05</b>	0.01	<b>1.04 (1.02,1.07)</b> (n=563)	<b>&lt;0.001</b>	0.03	<b>1.05 (1.02,1.09)</b> (n=609)	<b>0.002</b>	0.03
	Adjusted <sup>a</sup>	<b>1.03 (1.00,1.06)</b> (n=489)	<b>0.05</b>	0.01	<b>1.04 (1.01,1.06)</b> (n=554)	<b>0.001</b>	0.05	<b>1.05 (1.01,1.08)</b> (n=599)	<b>0.006</b>	0.05

Figure 1: Associations between Y1 BMI & WC for Y10 SRKOA incidence

(BMI & WC adjusted for Y1 age and knee injury)

