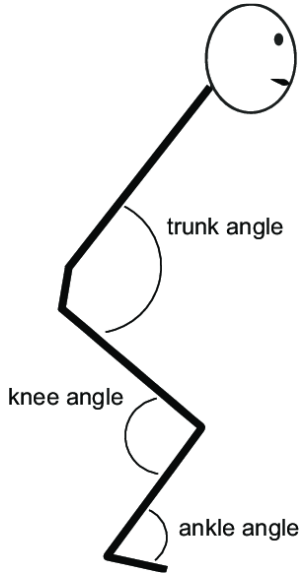
Can a Smartphone recorded video analyzed by ai **predict ostheoarthisis** using of using trunk maximums lean angle?



A **higher maximum trunk-lean angle** during the **Five Times Sit-to-Stand (FTSTS) test** is associated with **greater odds of an osteoarthritis diagnosis**, with each additional degree conferring a **6 % increase in odds**. This relationship remains significant **after adjusting for** key demographic and functional covariates; however, **the effect size is modest**. Consequently, a maximum trunk-lean angle is clinically informative only **in settings where osteoarthritis is prevalent**. In the United States, osteoarthritis prevalence is highest among adults **65 years and older** (Callahan et al., 2021; Ogunsola et al., 2024).

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BRIEF COMMUNICATION OPEN

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Smartphone videos of the sit-to-stand test predict osteoarthritis and health outcomes in a nationwide study

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Physical function decline due to aging or disease can be assessed with quantitative motion analysis, but this currently requires expensive laboratory equipment. We introduce a self-guided quantitative motion analysis of the widely used five-repetition sit-to-stand test using a smartphone. Across 35 US states, 405 participants recorded a video performing the test in their homes. We found that the quantitative movement parameters extracted from the smartphone videos were related to a diagnosis of osteoarthritis, physical and mental health, body mass index, age, and ethnicity and race. Our findings demonstrate that at-home movement analysis goes beyond established clinical metrics to provide objective and inexpensive digital outcome metrics for nationwide studies.

npj Digital Medicine (2023)6:32 ; https://doi.org/10.1038/s41746-023-00775-1

Opensource

Github

sit2stand.ai

TERMS FAQ

Analyze sit-to-stand movement from smartphone video

ASSESS

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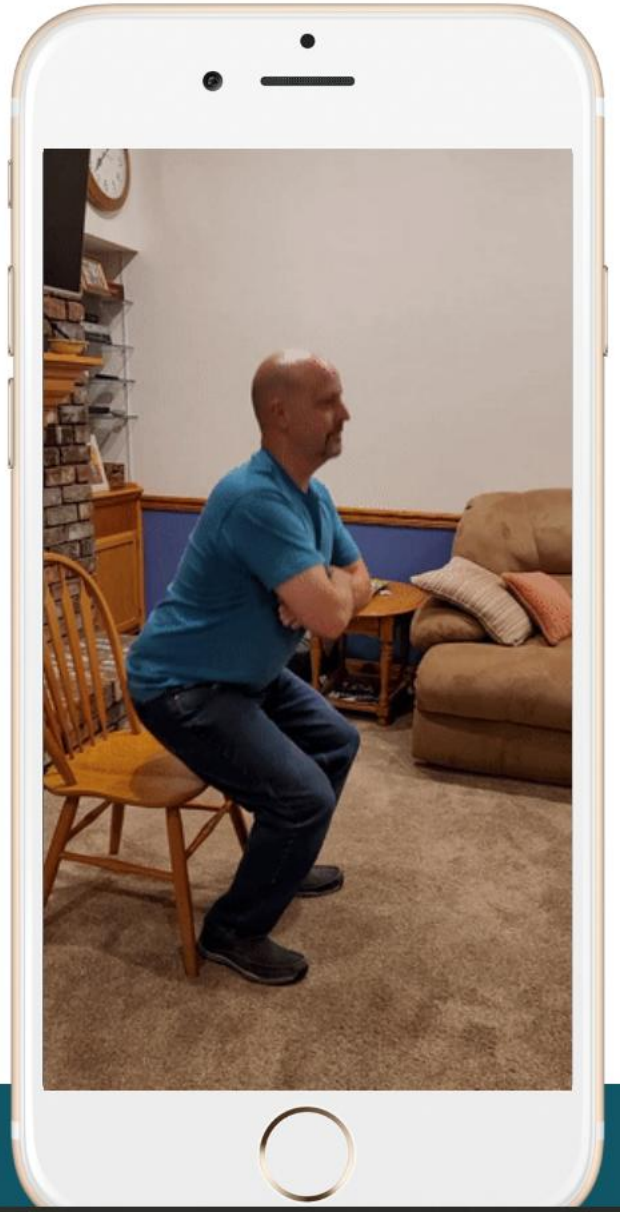
Stanford University



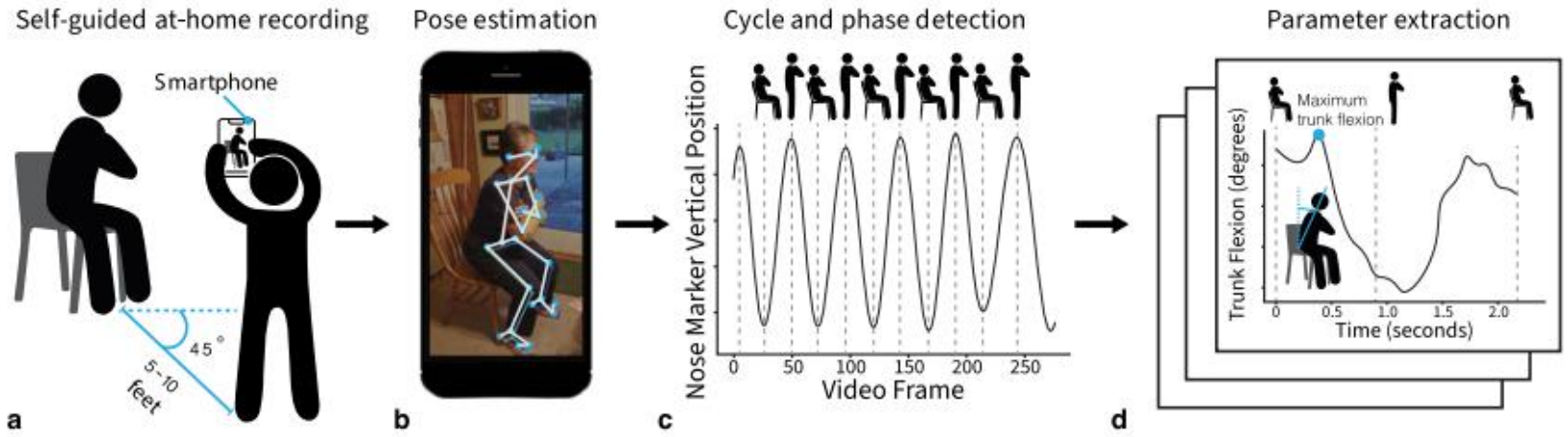


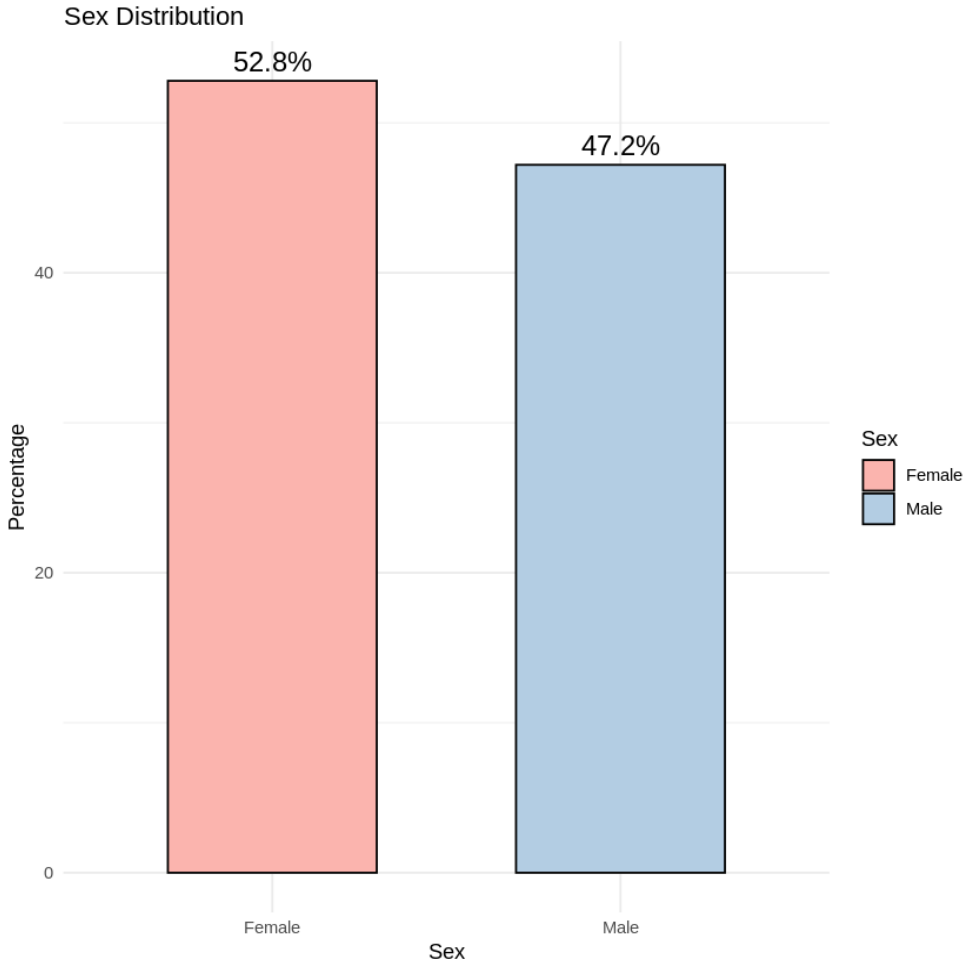
Fig. 1 An overview of our web application to collect and analyze movement data. a Participants perform the five-repetition sit-to-stand test while an untrained individual records the test using only a smartphone or tablet from a 45-degree angle to capture a combined sagittal and frontal view. **b** The video is uploaded to the cloud and a computer vision algorithm, OpenPose[12], computes body keypoints throughout the movement. **c** Our tool computes the key transitions in each STS cycle (i.e., as the participant rises from the chair and returns to sitting). **d** Our algorithms compute the total time to complete the test and several important biomechanical parameters, like trunk angle (see Methods for details). Note: the photograph in (**b**) is an actor, not a study participant, who consented for their photo to be used in the publication.

Characteristics and demographics

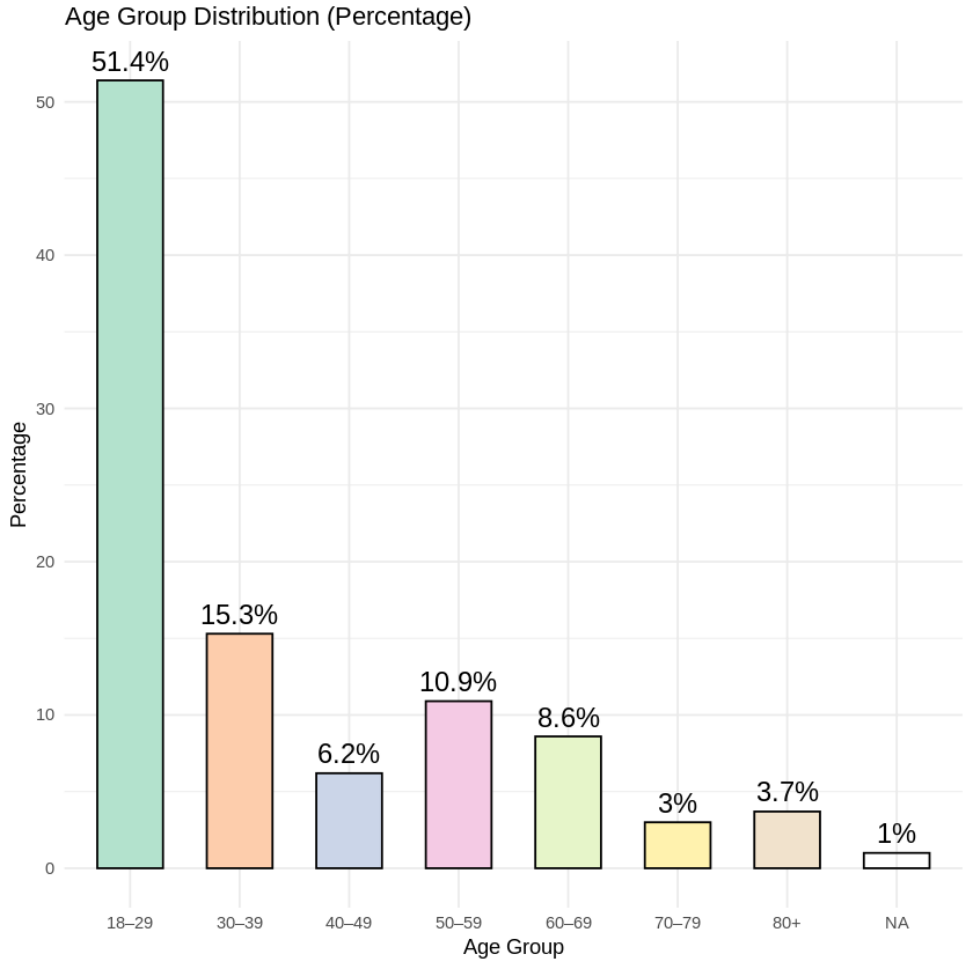
Osteoarthritis (n=375)	Percentage (%)
No	92.6
Yes	7.4

Variable	Mean (SD)
Age	37.29 (17.81)
BMI	24.21 (4.19)

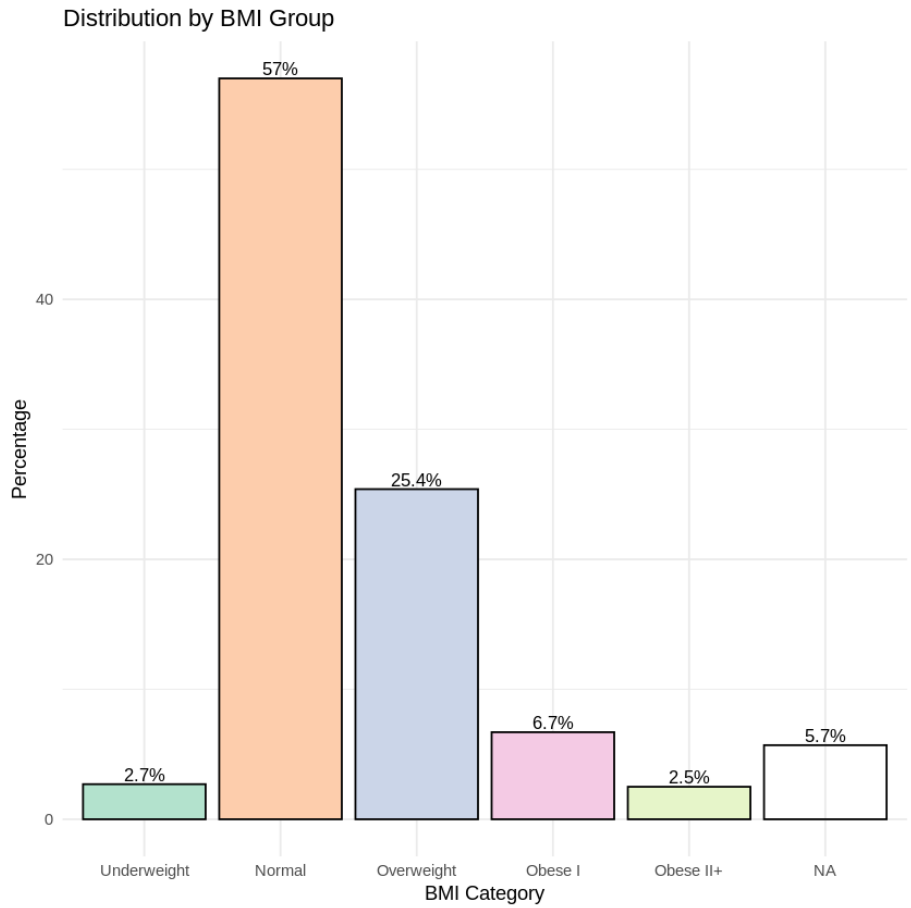
Of the 375 participants, only 7.4 % had osteoarthritis. Most were young adults—over half were 18–29 years old, while only about 15 % were 60 +—and their average BMI was 24.2 kg/m² (normal-weight range)



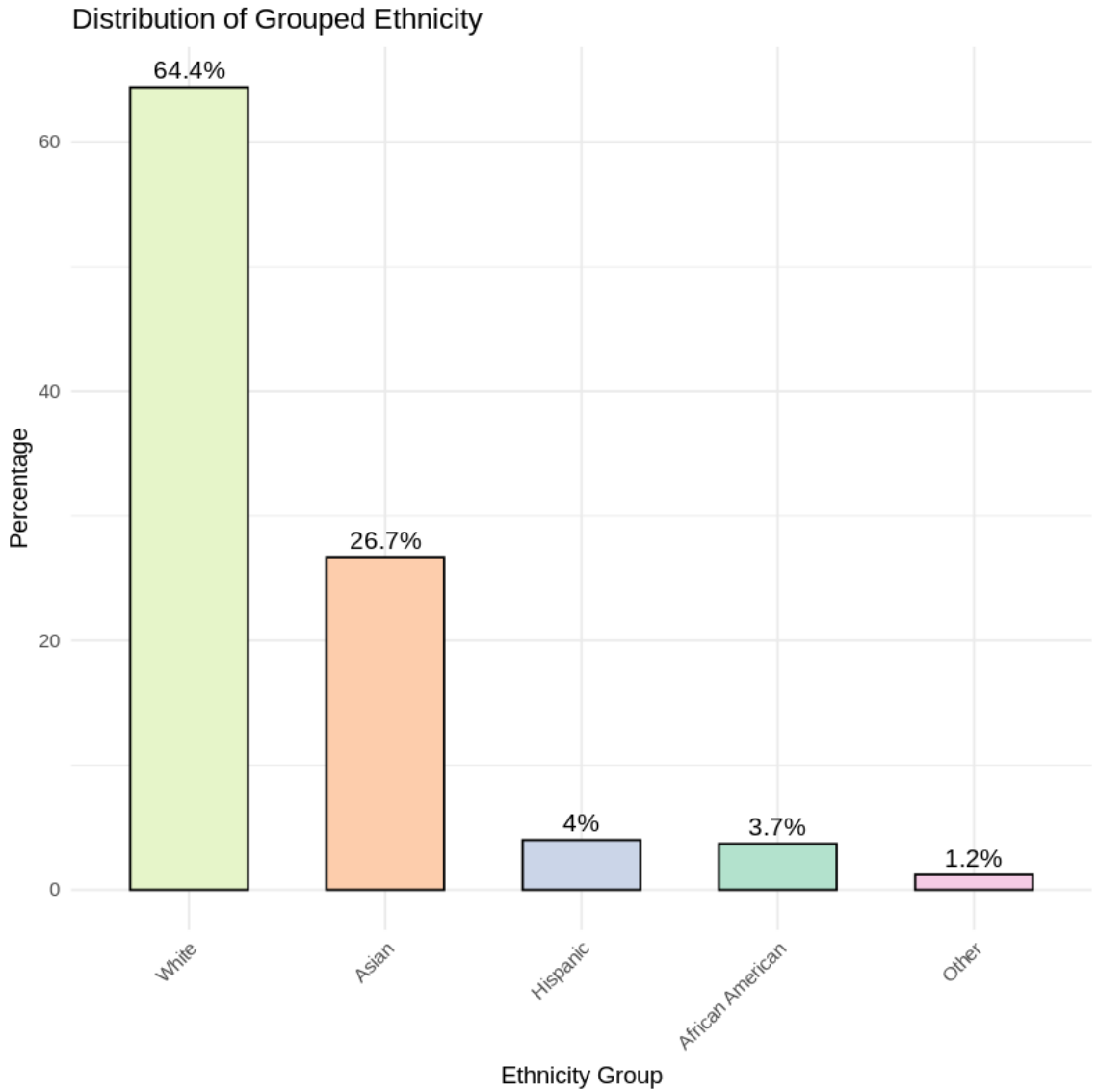
Females were 52.8 % of the sample, while males accounted for 47.2 %, indicating a near-even sex distribution. The slight 5.6-percentage-point female predominance suggests minimal sex imbalance in the cohort.



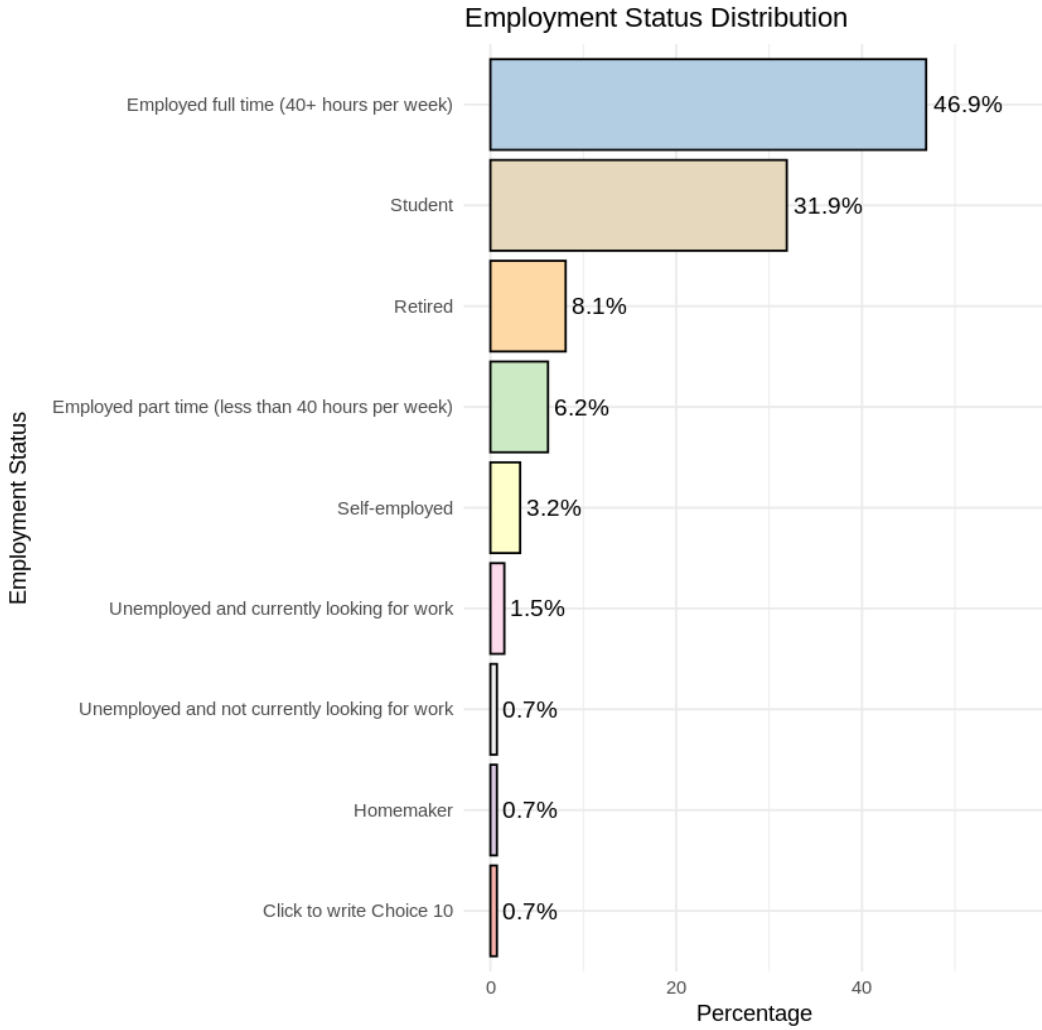
Most participants (51.4 %) are aged 18–29. Adults aged 60 and above account for only about 15 % of the cohort.



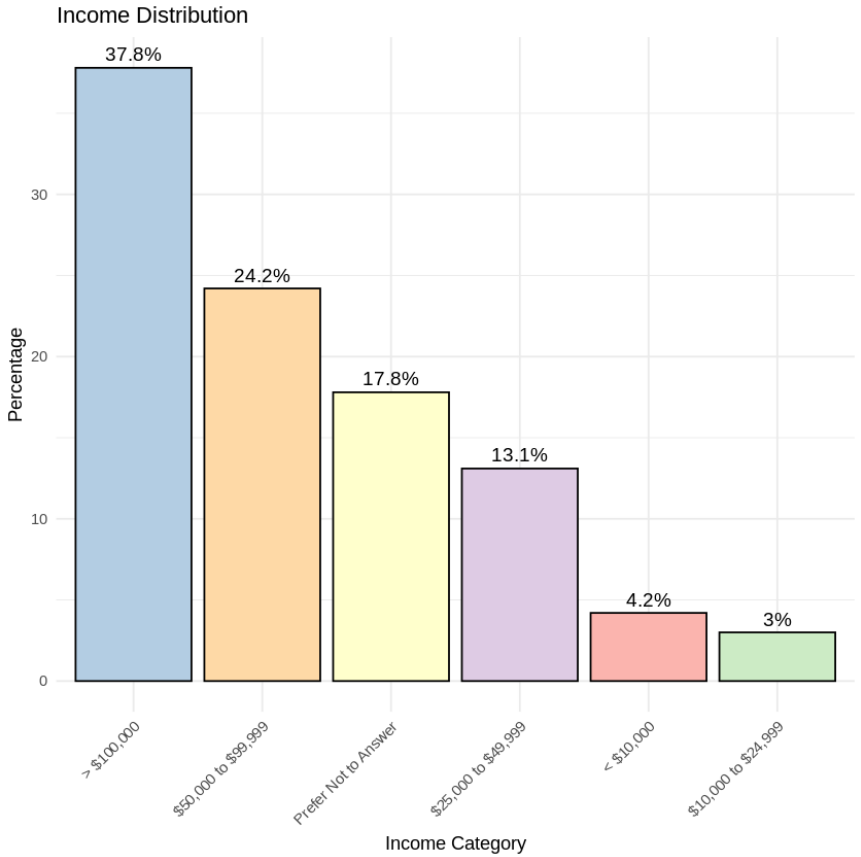
Most participants fall in the **normal-weight** range (57 %). About a quarter are **overweight** (25 %), while relatively few are **obese** (Obese I: 6.7 %; Obese II+: 2.5 %) or **underweight** (2.7 %).



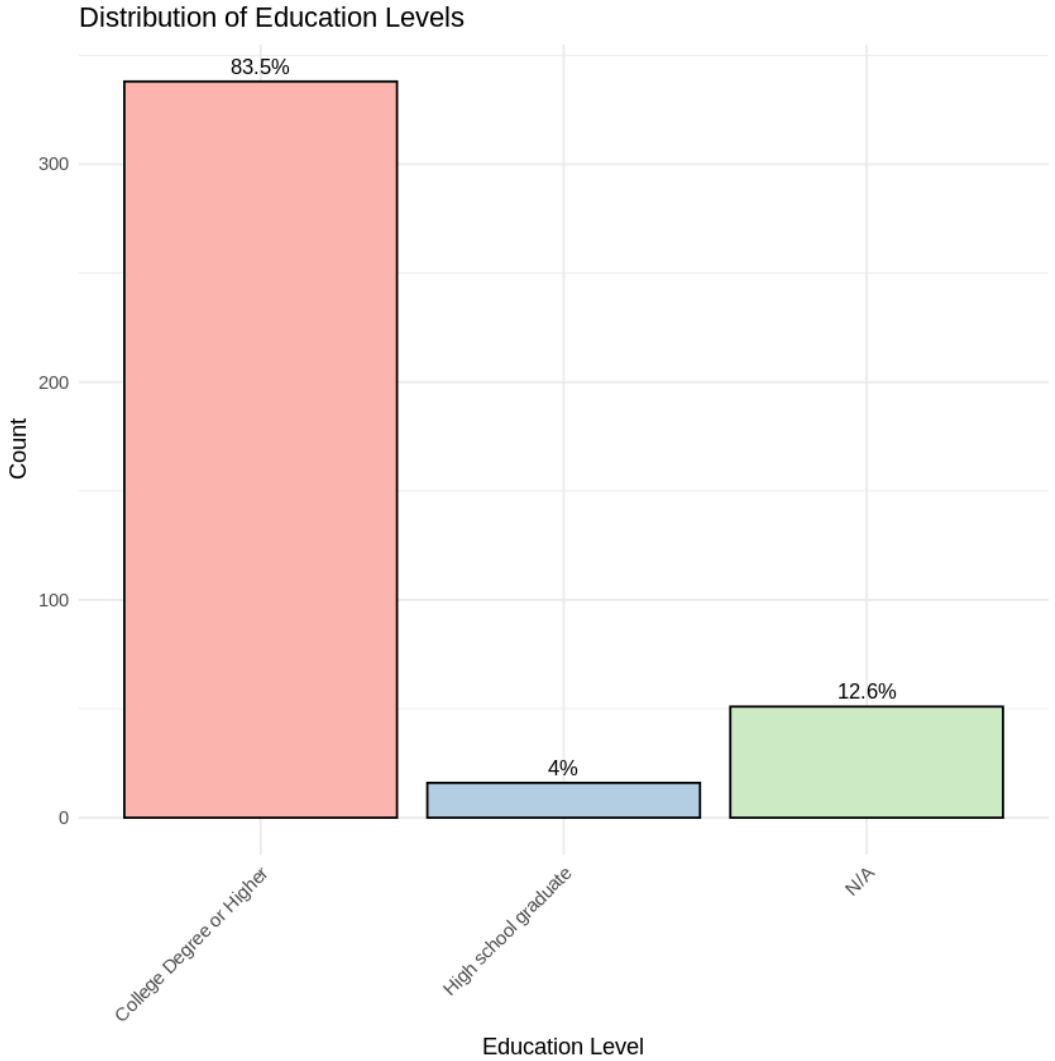
Nearly two-thirds of participants identify as White (64.4 %), while Asians represent about one-quarter (26.7 %). Hispanic, African American, and Other groups each account for less than 5 %, indicating limited ethnic diversity beyond the two largest categories.



Almost half of the participants work full-time (46.9 %), and another third are students (31.9 %), leaving only a small minority in other categories (retired 8.1 %, part-time 6.2 %, self-employed 3.2 %, and < 2 % across all forms of unemployment, homemaking, or uncategorised responses).

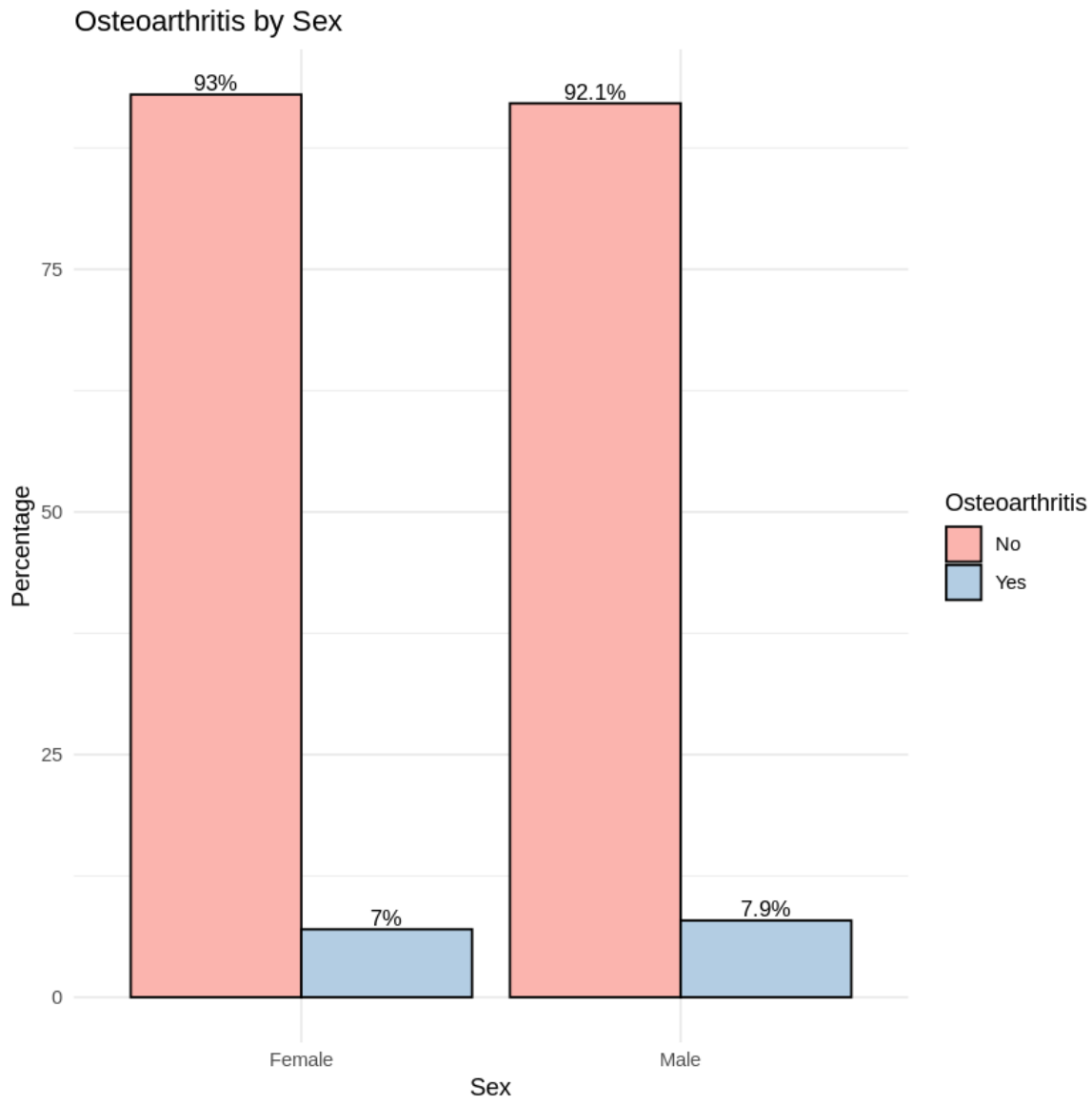


Nearly two-fifths of participants report annual incomes above $100 000 (37.8 %), and another quarter fall in the $50 000–$99 999 range (24.2 %). Lower-income brackets (< $25 000) together account for only about 7 %, while 17.8 % chose not to disclose their income.

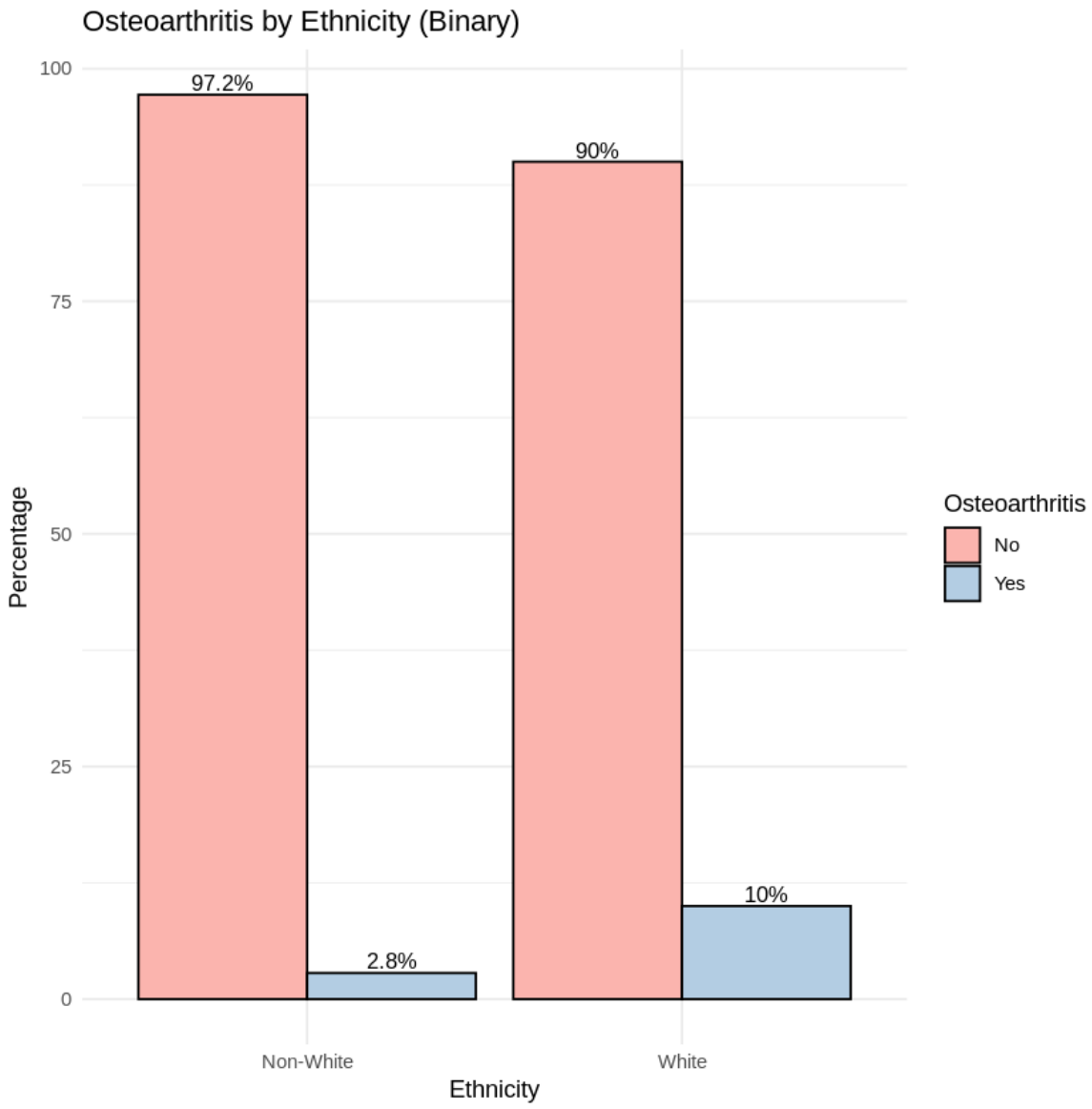


More than four-fifths of participants hold a college degree or higher (83.5 %), while only 4 % report a high-school education as their highest level.

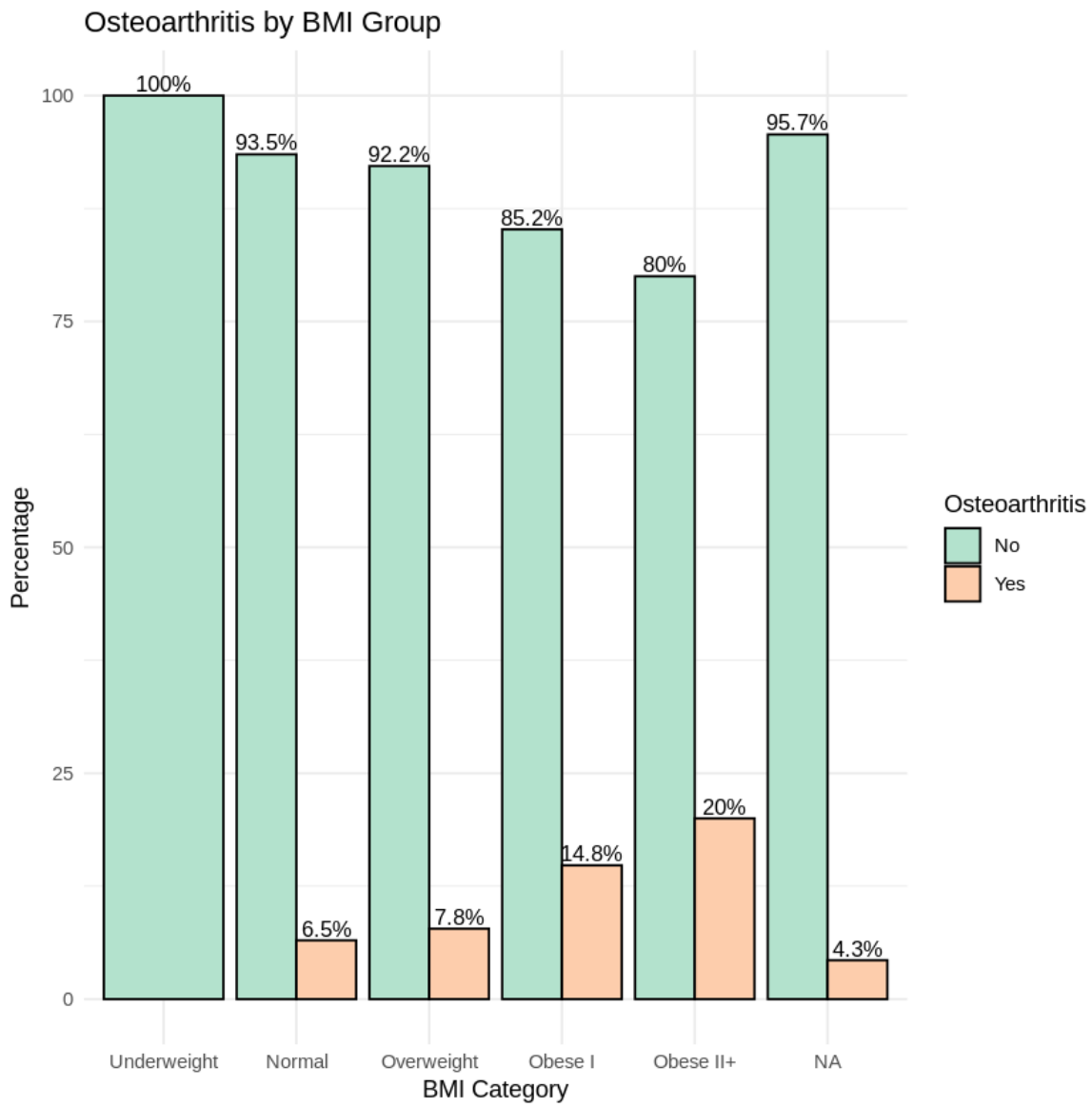
Bivariable analysis



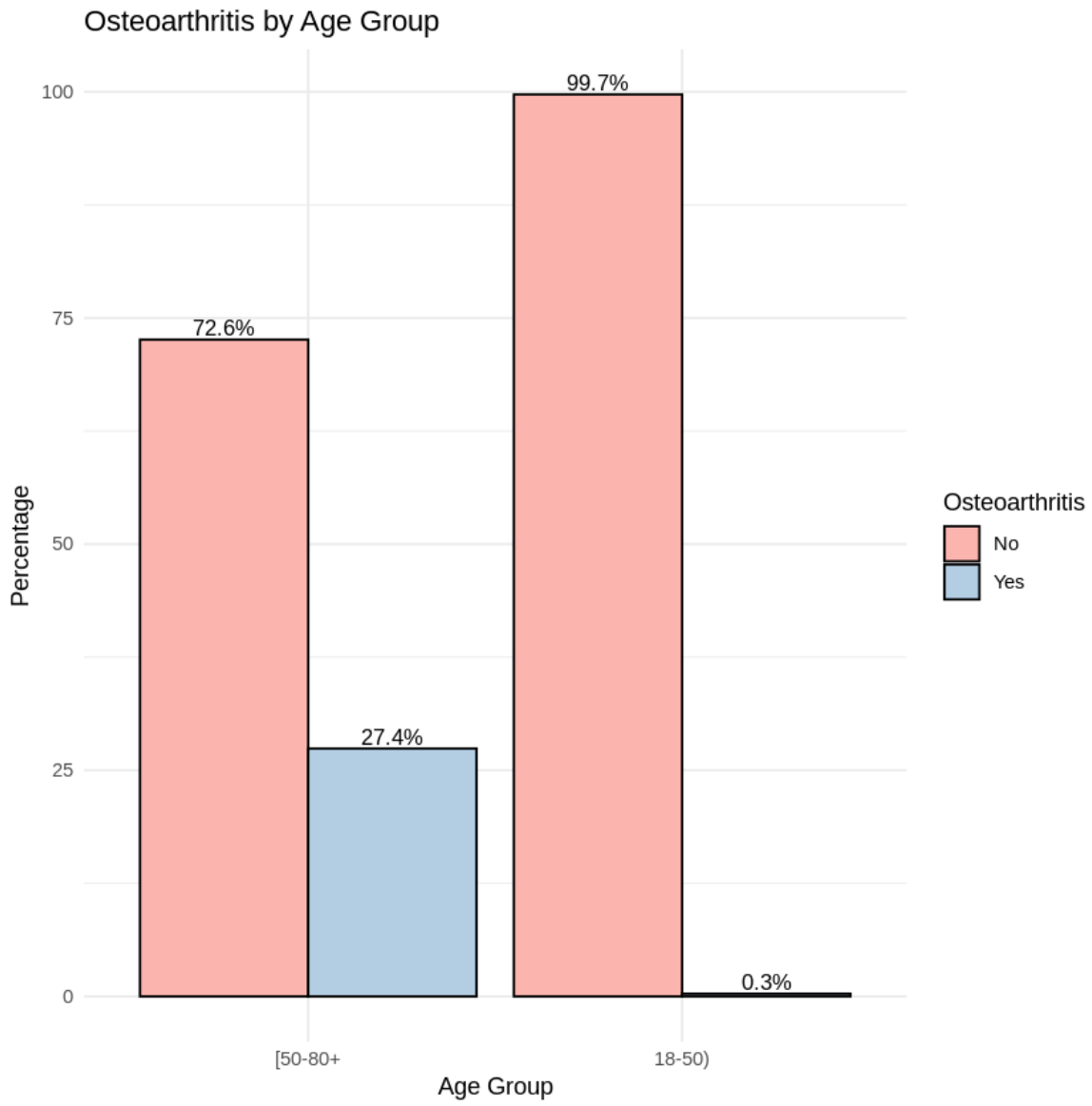
Osteoarthritis prevalence is low in both sexes—about 7 % in females and 8 % in males—indicating no meaningful sex difference. The vast majority (> 92 %) of participants in each group report no osteoarthritis.



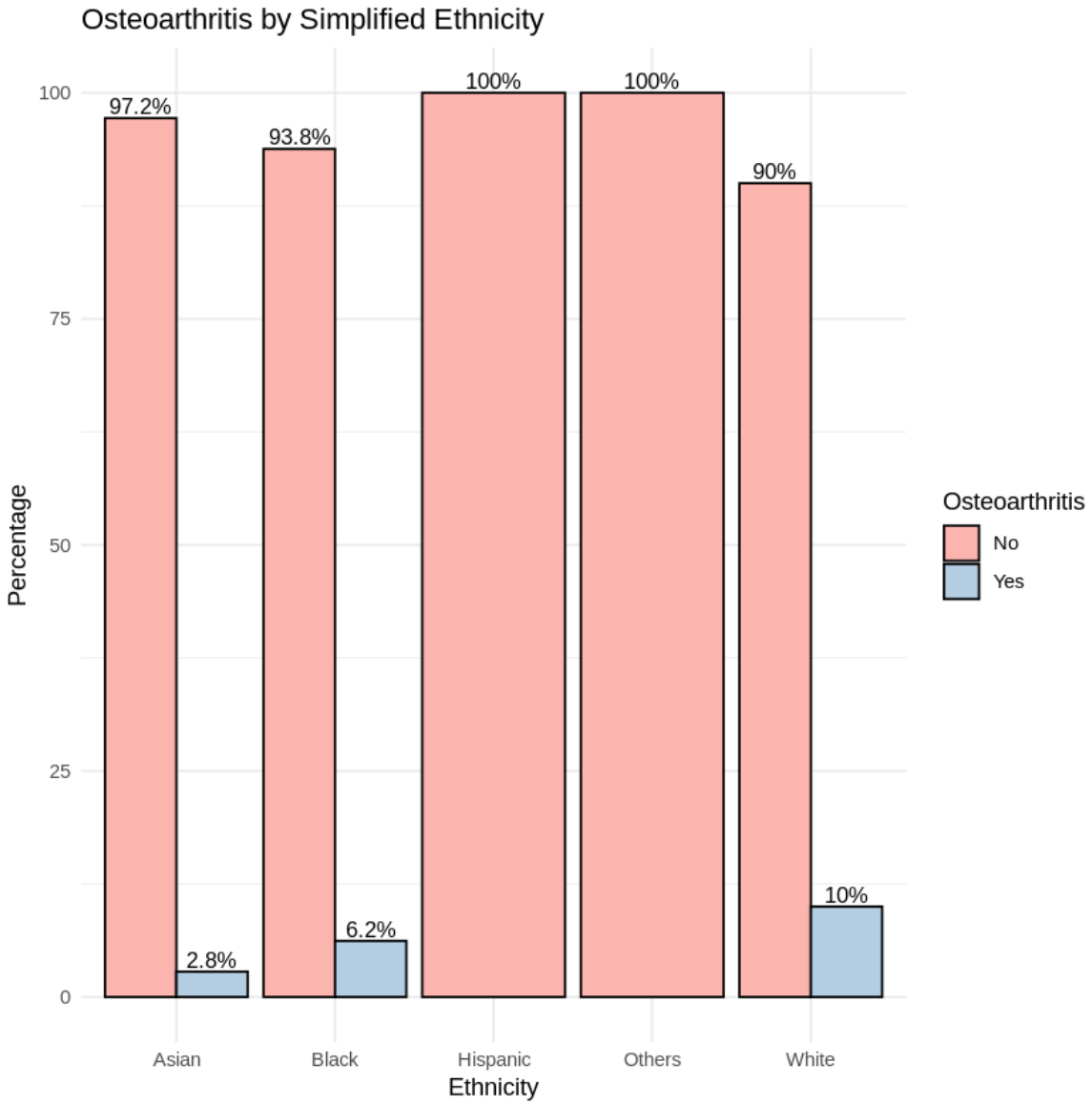
Osteoarthritis is notably more common among White participants (10 %) than Non-White participants (2.8 %). Even so, over 90 % of each ethnic group reports no osteoarthritis.



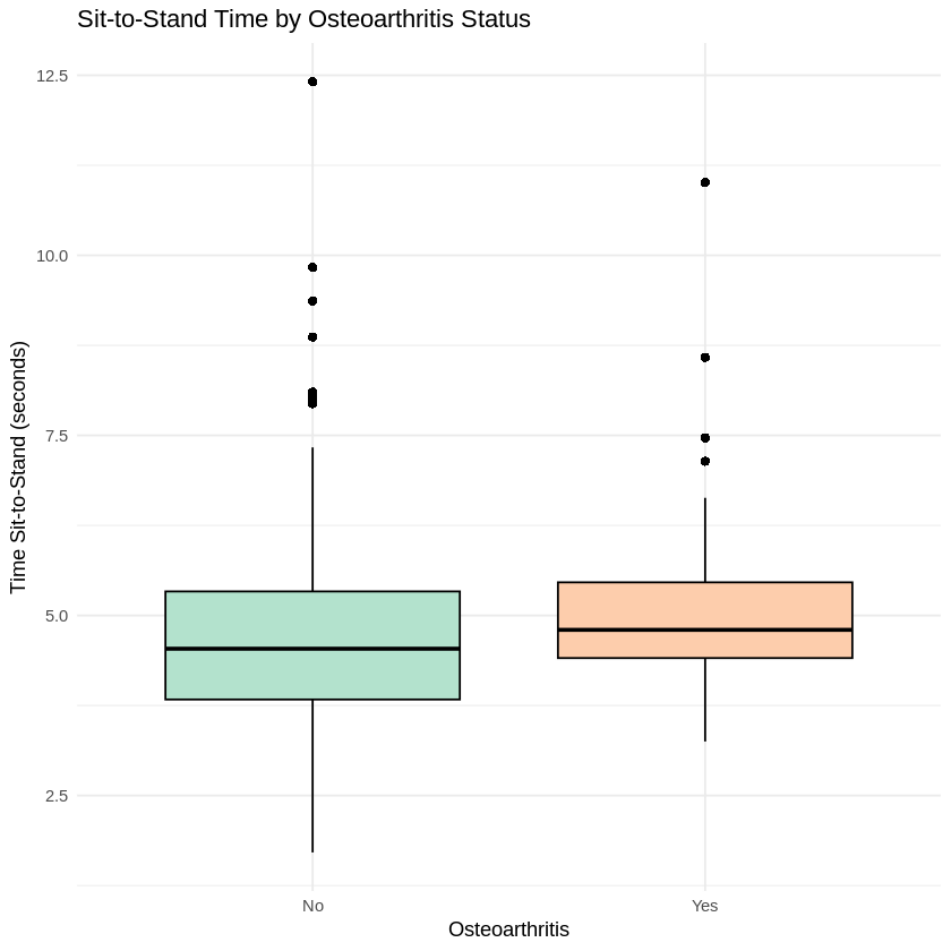
Osteoarthritis prevalence rises with increasing BMI: none in underweight participants, 6–8 % in normal/overweight groups, and up to 20 % in the highest obesity class, suggesting a dose-response relationship between higher BMI and OA risk



Osteoarthritis is almost exclusive to participants aged ≥ 50, affecting roughly one-quarter of this group, whereas it is virtually absent (< 1 %) among those 18–50 years.

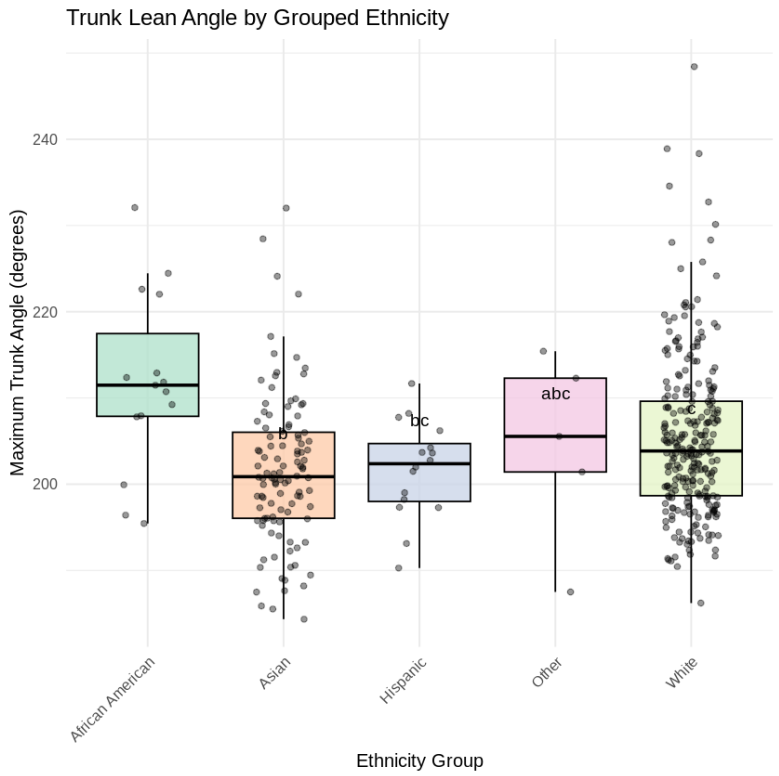


Osteoarthritis is most common among White participants (~10 %), whereas all other ethnic groups show very low prevalence (≤ 6 %).



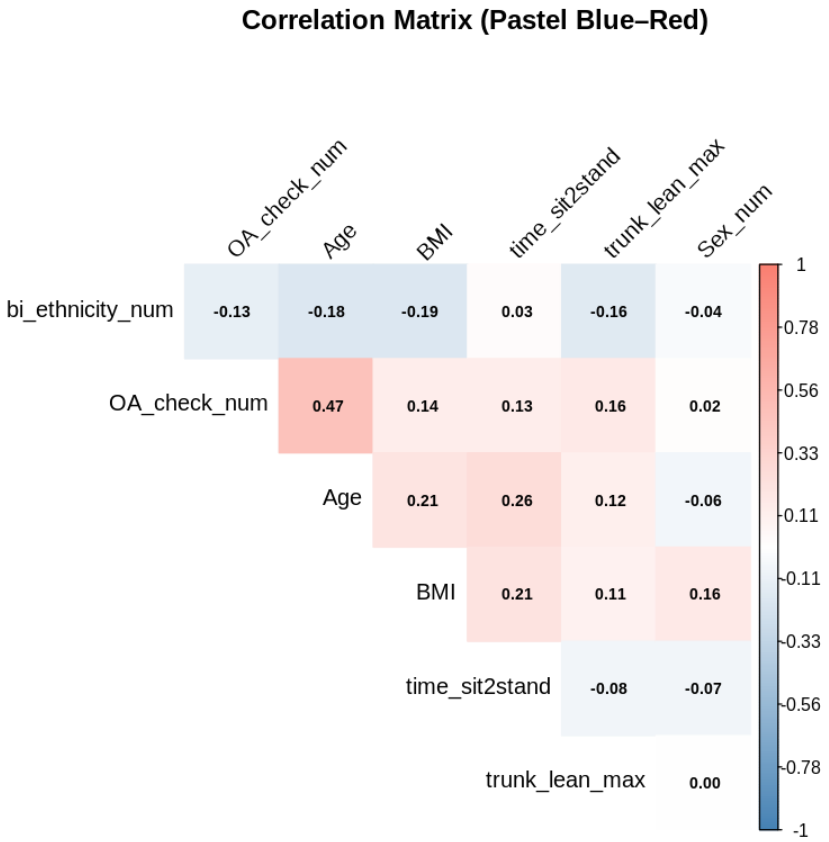
OA	n	Mean ± SD	Median [IQR]	Range
Yes	30	5.30 ± 1.56	4.80 [4.41 – 5.46]	3.25 – 11.01
No	375	4.66 ± 1.25	4.54 [3.83 – 5.33]	1.71 – 12.41

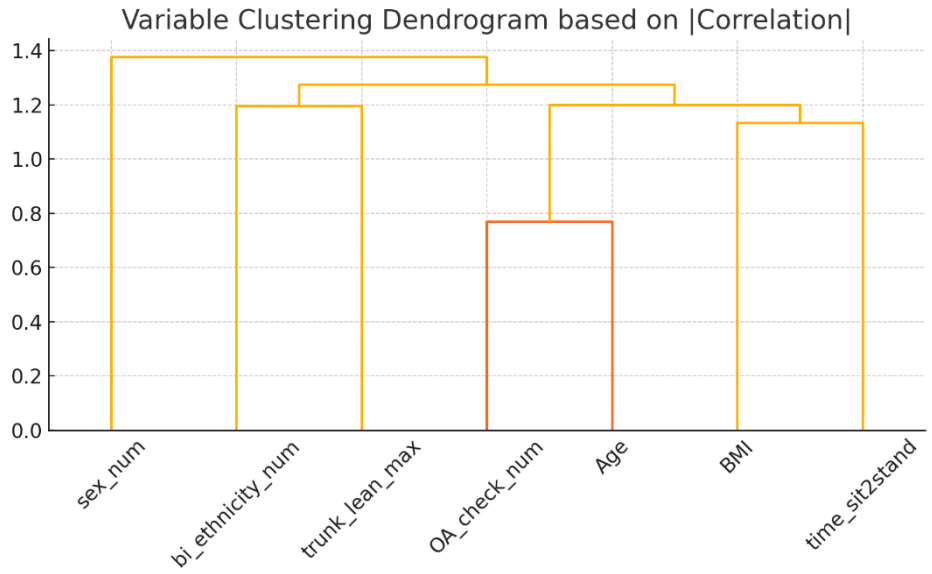
Participants with osteoarthritis took slightly longer to complete the sit-to-stand (median ≈ 5 s) than those without osteoarthritis (median ≈ 4.5 s), and their spread of times is wider, with several outliers above 7 s. However, the overlap between the interquartile ranges suggests only a modest difference in functional performance.



African-American participants exhibit the highest median trunk-lean angle (~210°), whereas Asian and Hispanic groups show slightly lower medians (~200–202°); however, the interquartile ranges overlap considerably, indicating only modest ethnic differences in maximum trunk-lean during the sit-to-stand task.

Ethnicity group	*n*	Median (°)	IQR (°)	Approx. range (°)
African American	~20	**210**	200 – 220	195 – 230
Asian	~100	**200**	195 – 205	185 – 225
Hispanic	~15	**202**	197 – 206	190 – 212
Other	~10	**205**	200 – 210	190 – 215
White	~230	**204**	195 – 218	185 – 240





The correlation matrix reveals that **Age** has the strongest association, showing a moderate positive correlation with **Ostheoarthisis** (r ≈ 0.47), indicating that older participants are somewhat more likely to have an osteoarthritis diagnosis. All other relationships are weak: **Age–time_sit2stand** (r ≈ 0.26), **Age–BMI** (r ≈ 0.21), **BMI–time_sit2stand** (r ≈ 0.21), and **Ostheoarthisis –trunk_lean_max** (r ≈ 0.16). Minor negative correlations appear between **Ethnicity** (white, non white) and both **Age** (r ≈ –0.18) and **BMI** (r ≈ –0.19), while **time_sit2stand–trunk_lean_max** shows a very small inverse relationship (r ≈ –0.08).

LOGISTIC REGRESSION

MULTIVARIABLE LOGISTIC REGRESSION

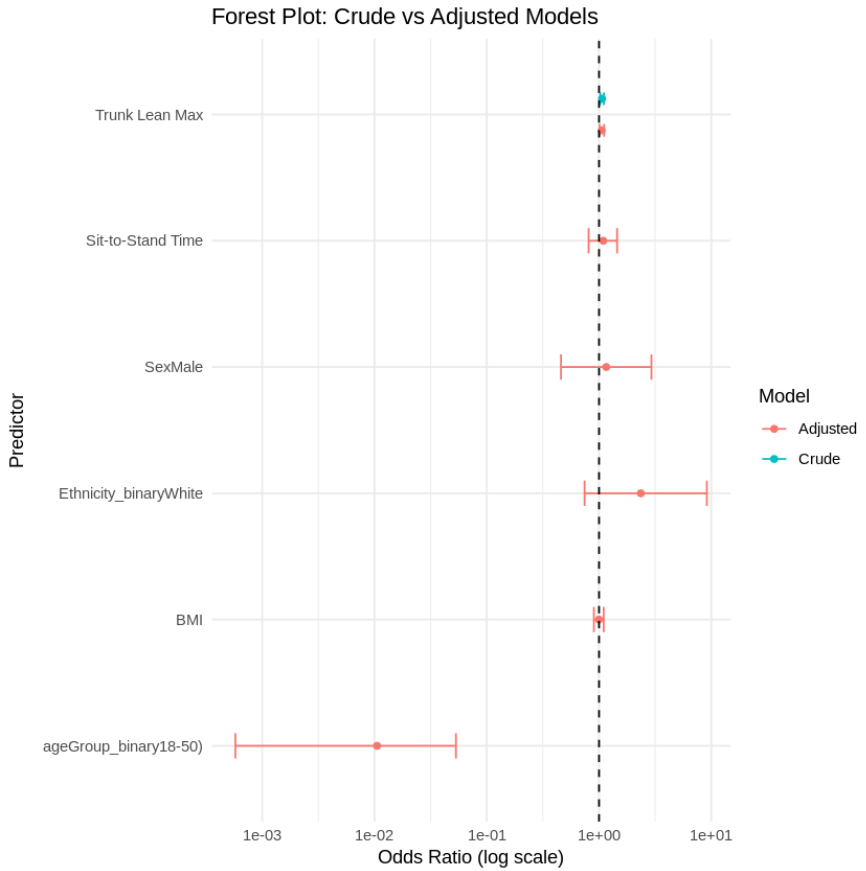
STEP 1- Cluster model

$$\operatorname{logit}\left[P(\mathrm{OA}=1)\right] = \beta_0^{\mathrm{crude}} + 0.058\,\left(\text{Trunk-Lean Max, }^{\circ}\right)$$

STEP 2 – Adjusted model

Baseline (reference) category = **Female, Non-White, Age 50–80 y**

$$\begin{aligned}\operatorname{logit}\left[P(\mathrm{OA}=1)\right] = \beta_0^{\mathrm{adj}} \\ + \ 0.058\,(\text{Trunk-Lean Max, }^{\circ}) \\ + \ 0.148\,(\text{Sex} = \text{Male}) \\ + \ 0.860\,(\text{Ethnicity} = \text{White}) \\ - \ 4.605\,(\text{Age 18–50 y}) \\ + \ 0.086\,(\text{Sit-to-Stand Time, s}) \\ + \ 0.000\,(\text{BMI, kg m}^{-2})\end{aligned}$$



Characteristic	Crude Model OR	Crude Model 95% CI	Crude Model p-value	Adjusted Model OR	Adjusted Model 95% CI	Adjusted Model p-value
Trunk Lean Max	1.06	1.03, 1.10	<0.001	1.06	1.01, 1.11	0.016
Sex						
Female				—	—	
Male				1.16	0.46, 2.93	0.8
Ethnicity						
Non-White				—	—	
White				2.36	0.74, 9.13	0.2
Age Group						
[50-80+				—	—	
18-50)				0.01	0.00, 0.05	<0.001
Sit-to-Stand Time				1.09	0.81, 1.45	0.6
BMI				1.00	0.90, 1.10	>0.9

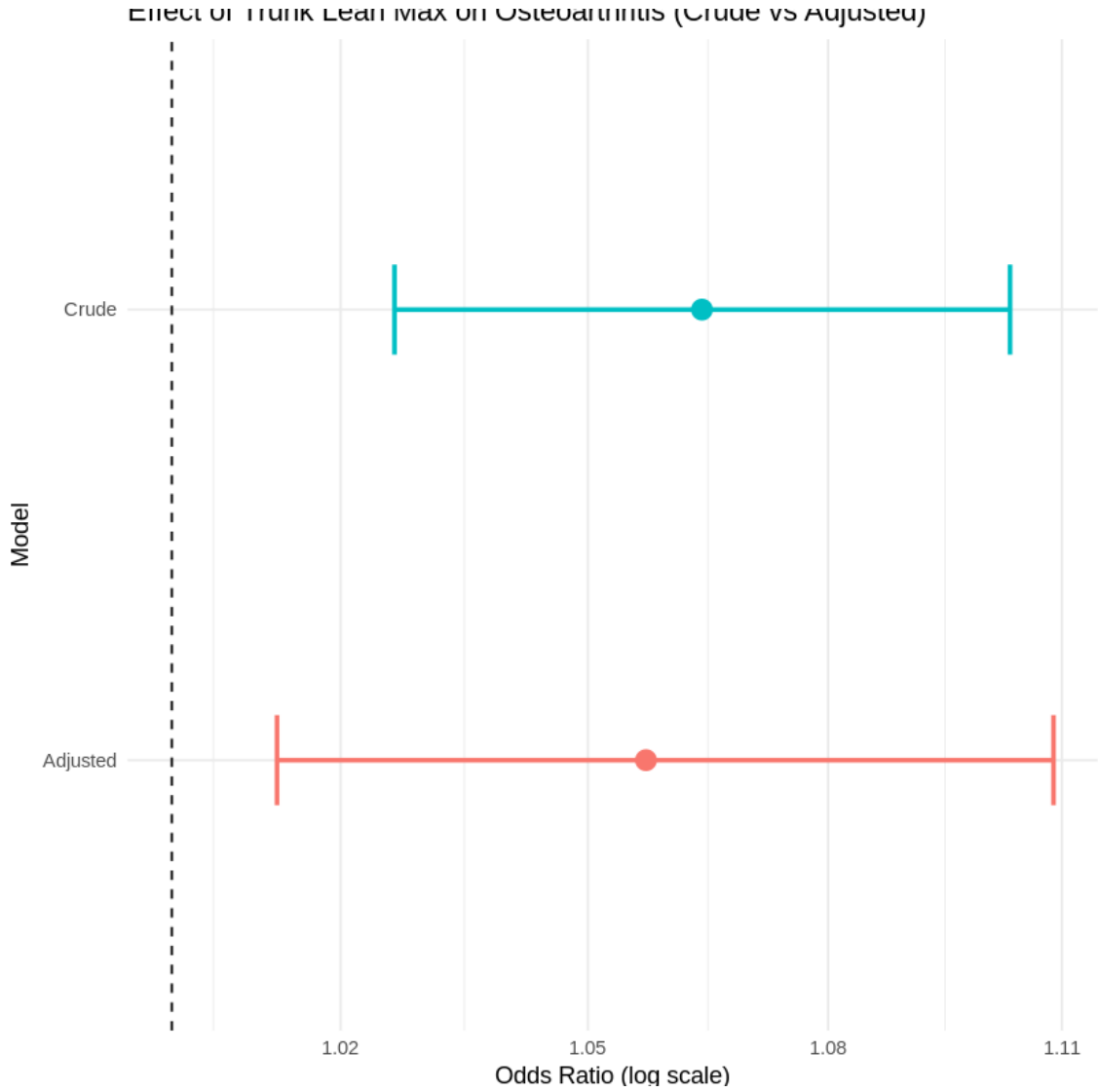
Abbreviations: CI = Confidence Interval, OR = Odds Ratio

After adjustment, **higher trunk-lean max remains a statistically significant predictor** of osteoarthritis (OR ≈ 1.06 per °; CI clear of 1), whereas **younger age (18–50 y)** is strongly protective (OR ≈ 0.01). Sit-to-stand time, BMI, male sex, and White ethnicity all have confidence intervals that cross the null line, indicating **no independent association**. The crude and adjusted estimates for trunk-lean are almost identical, suggesting this biomechanical measure contributes information beyond demographic and functional covariates.

In the fully adjusted model, every extra degree of trunk-lean increases the odds of an osteoarthritis diagnosis by 6 % (OR = 1.06, 95 % CI 1.01–1.11, p = 0.016). Age is the dominant covariate: participants aged 18–50 have 99 % lower odds of OA than those ≥ 50 (OR = 0.01, p < 0.001). Sex, ethnicity, sit-to-stand time, and BMI show no independent association, as their confidence intervals all include 1 and p-values exceed 0.05.

RESULTS

Both models show that trunk-lean angle is an independent—but small—predictor of osteoarthritis: each additional degree of forward lean raises the odds of diagnosis by roughly 6 % (crude OR ≈ 1.06, 95 % CI ≈ 1.02–1.10; adjusted OR ≈ 1.06, 95 % CI ≈ 1.01–1.11). The near-identical crude and adjusted estimates indicate that this biomechanical effect persists after controlling for age, BMI, sex, ethnicity, and sit-to-stand time.



DISCUSSION

- **Smartphone alternative** – A single smartphone video of the Five-Times Sit-to-Stand test captures trunk-lean, replacing costly gait-lab equipment.
- **Biomechanical signal** – Each additional degree of forward trunk-lean increases osteoarthritis (OA) odds by ≈ 6 %.
- **Age gradient** – OA is rare below 50 years and rises sharply thereafter [5].
- **Sex & ethnicity trend** – Non-significant hints of higher OA risk in women and White adults echo prior reports [2, 4].
- **FAIR gap** – Six identically named trunk-lean columns and Python-only access break “Interoperable” and “Reusable” principles [1], hampering replication of the smartphone workflow.
- **SES under-representation** – High-income, well-educated participants dominate the sample, yet low socio-economic status—an even stronger OA predictor [3]—is under-sampled, limiting generalisability.

REFERENCE

1.Wilkinson M D, Dumontier M, Aalbersberg IJ et al. **The FAIR Guiding Principles for scientific data management and stewardship**. *Sci Data*. 2016;3:160018.

2.de Medeiros M, Martins B, Ferreira C et al. **Gender and sex are key determinants in osteoarthritis**. *Biomolecules*. 2021;11:1161.

3.Hawker GA, Croxford R, Bierman AS et al. **Socio-economic status and the risk of developing hand, hip or knee osteoarthritis**. *Osteoarthritis Cartilage*. 2015;23:1323-1329.

4.Jordan JM, Helmick CG. **Racial and ethnic disparities in osteoarthritis phenotypes**. *Curr Opin Rheumatol*. 2010;22:528-532.

5.Katz JN, Arant KR, Loeser RF. **Epidemiology and burden of osteoarthritis**. *Nat Rev Rheumatol*. 2013;9:552-559.