UNIVERSITY OF TEXAS AT EL PASO

College Of Health Science

Selected Topics-Public Health (PUBH-5357)

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FINAL PROJECT

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May 2025

Research Question

Can Smartphone-recorded maximum lean trunk angle analyzed by artificial intelligence (AI) predict osteoarthritis diagnosis?

Brief Summary of Results

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, 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).

Approach

The dataset derives from a project that developed an OpenSim–based, smartphone motion-analysis platform with an open-source website for uploading and analyzing Five-Times Sit-to-Stand (FTSTST) videos alongside online demographic and health surveys (Boswell et al., 2023). This study integrates two-dimensional OpenPose analyses with home-based FTSTST assessment, leveraging the rapid and widespread adoption of smartphones (Silver & Taylor, 2019) and recent advances in video-based pose-estimation algorithms that have greatly improved the precision and accessibility of motion analysis (Cao et al., 2021; Mathis et al., 2018). Accurate 2-D movement quantification from smartphone recordings has been demonstrated in laboratory (Stenum, Rossi, & Roemmich, 2021), clinical (Kidziński, 2020), and home-based exoskeleton- and Kinect-enabled settings (Ejupi et al., 2015).

To evaluate the influence of kinematic features on health outcomes—specifically the prediction of osteoarthritis—the FTSTST was selected as a validated measure of lower-limb function, with established reliability, validity, and responsiveness in community-dwelling adults and in clinical populations including idiopathic pulmonary fibrosis (Trivedi et al., 2023), chronic obstructive pulmonary disease (Jones et al., 2013), heart failure (Ramos, 2022), and post-intensive-care survivors (Melo et al., 2022).

The dataset was chosen for its close alignment with the doctoral research objectives. It was obtained via a *Nature* journal link to a public GitHub repository—where a provided Python script was executed to download the CSV file—and, upon discovering the absence of a codebook, the team contacted the original authors, who supplied a revised CSV containing clear, textual variable labels.

The reproducibility assessment focused on whether maximum trunk lean—derived by AI from home-based smartphone video—predicts osteoarthritis diagnosis. Of four candidate variables indicating trunk lean (trunk_lean_range_mean, trunk_lean_max, trunk_lean_max_mean, trunk_max), trunk_lean_max was selected. Covariates comprised age, dichotomized as 19–50 years (reference) versus ≥ 50 years; BMI, calculated from height (inches → meters) and weight (pounds → kilograms); sex, coded female (reference) versus male; ethnicity, collapsed from ten categories into White, Black, Hispanic, and Asian and then dichotomized as White (reference) versus non-White; and total FTSTST duration. Logistic regression was then used to estimate the association between trunk_lean_max and osteoarthritis, adjusting for these covariates.

When the FAIR principles (Findable, Accessible, Interoperable, and Reusable) (Wilkinson et al., 2016) are applied to this dataset, several shortcomings become apparent. Findable: although the data are linked from a Nature article and hosted on GitHub, they lack a persistent identifier (e.g., DOI) and a standardized metadata registry, making discovery and citation difficult. Accessible: raw data can only be obtained by executing Python scripts against the repository—there is no direct download link or API, and licensing terms are not clearly documented. Interoperable: the data are provided as CSV and processed via OpenSim/OpenPose pipelines, yet four distinct "trunk_lean" columns share ambiguous names, and no machine-readable schema (e.g., JSON-LD) is supplied, hindering integration with other tools or languages. Reusable: the absence of an embedded codebook, unversioned analysis scripts, and limited provenance tracking prevent users from confidently interpreting or adapting the dataset for new studies.

Analysis and Results

1. Characteristics and demographics:

Of the 375 participants, only 7.4 % had osteoarthritis. The cohort was predominantly young, with 51.4 % aged 18–29 and merely 15 % aged 60 or older, and exhibited a near-even sex distribution (52.8 % female, 47.2 % male). Mean BMI was 24.2 kg/m² (normal-weight range), and 57 % of participants fell in the normal-weight category, 25 % were overweight, 6.7 % obese I, 2.5 % obese II+, and 2.7 % underweight. Ethnically, 64.4 % identified as White and 26.7 % as Asian; Hispanic, African American, and other groups each comprised less than 5 %. Employment status was dominated by full-time workers (46.9 %) and students (31.9 %), with retirees (8.1 %), part-time employees (6.2 %), and self-employed individuals (3.2 %) making up the remainder (< 2 % in unemployment, homemaking, or uncategorized roles). Annual incomes exceeded $100 000 for 37.8 % of respondents, $50 000–$99 999 for 24.2 %, and fell below $25

000 for about 7 %, while 17.8 % did not disclose income. Finally, 83.5 % of participants held at least a college degree, compared to 4 % whose highest education was high school.

2. Bivariate analysis

In this cohort of 375 adults, osteoarthritis (OA) prevalence was uniformly low across sexes (≈7 % in females vs. 7.9 % in males) and ethnic groups (10 % in Whites vs. 2.8 % in non-Whites), but exhibited a clear sections for BMI (0 % in underweight, 6–8 % in normal/overweight, and 20 % in Class II obesity). Age emerged as the strongest correlate: roughly 27 % of those ≥50 years had OA compared with <1 % of participants aged 18–50 ($r \approx 0.47$ with OA status). Functionally, OA cases were slower on the Five-Times Sit-to-Stand test (median 5.0 s vs. 4.5 s), and ethnic differences in maximum trunk-lean angle were modest (African Americans ≈210°, Asians/Hispanics ≈200–202°), with all interquartile ranges overlapping.

Secondary correlations—such as Age–time_to_stand ($r \approx 0.26$), Age–BMI ($r \approx 0.21$), BMI–time_to_stand ($r \approx 0.21$) and OA–trunk_lean_max ($r \approx 0.16$)—were weak ($|r| \leq 0.26$), indicating minimal multicollinearity and underscoring the independent, albeit small, predictive value of trunk-lean in multivariable models.

3. Multivariable regression analysis

In multivariable logistic regression, each additional degree of maximum trunk-lean was independently associated with a 6 % increase in the odds of an osteoarthritis diagnosis (adjusted OR 1.06, 95 % CI 1.01–1.11; p = 0.016), with virtually identical estimates in the crude model (OR 1.06, 95 % CI 1.02–1.10; p < 0.001). Age 18–50 years was strongly protective (adjusted OR 0.01, 95 % CI 0.00–0.05; p < 0.001), whereas sit-to-stand time, BMI, male sex, and White ethnicity showed no independent associations (all 95 % CIs including 1 and p > 0.05).

Discussion

In this cohort, AI-derived maximum trunk-lean—captured from a simple smartphone FTSTST video—emerged as a modest but independent predictor of osteoarthritis: each extra degree increased the odds by about 6% even after adjusting for age, BMI, sex, ethnicity, and sit-to-stand time. Although statistically robust, the maximum trunk-lean effect is modest and its translational value is limited by data-transparency issues: the raw file contains four almost identically named trunk variables, and extracting the correct field requires previous knowledge of Python code. Consequently, the dataset fails the Interoperable and Reusable components of the FAIR principles (Wilkinson et al., 2016). Unique variable names, a machine-readable

data dictionary, and deposition in a repository that supports standard formats (e.g., CSV) would remedy these shortcomings.

Age finding is consistent with established epidemiology showing the rise in OA prevalence after mid-life (Hawker et al., 2015). While sex and ethnicity were not significant here, the positive direction for females and white participants contradicts the higher OA incidence and greater surgical utilization in white women (Jordan & Helmick, 2015). Importantly, emerging evidence points to socio-economic status (SES), especially low education and income, as a stronger, independent risk modifier than sex or race (Lee et al., 2021). Because this dataset is predominantly college-educated and higher-income, SES effects may have been attenuated, contributing to the overall low OA prevalence (7 %).

At the same time, the modest effect size cautions against just taken in consideration trunk-lean alone suggests that the screening protocols should combine it with other digital measures or patient-reported outcomes to reduce false positives and communicate results clearly. Future work should validate this approach in more diverse, lower-SES populations and explore how best to integrate trunk-lean feedback into telehealth platforms for personalized monitoring and early intervention.

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