

The relationship between osteoarthritis and bone mineral density in UK military personnel with and without lower limb loss in the ADVANCE cohort

Dr Fraje Watson, PhD
Maj Oliver O’Sullivan, PhD
Prof Anthony Bull, PhD
Gp Cpt (Prof) Alexander Bennett, PhD FRCP

Introduction
Osteoarthritis (OA) and low bone mineral density (BMD) are both important musculoskeletal diseases with significant personal and socioeconomic impact (1). These processes have both convergent and divergent risk factors (2) (Fig.1) that overlap further with current knowledge on OA and BMD in people with lower limb loss (3,4).

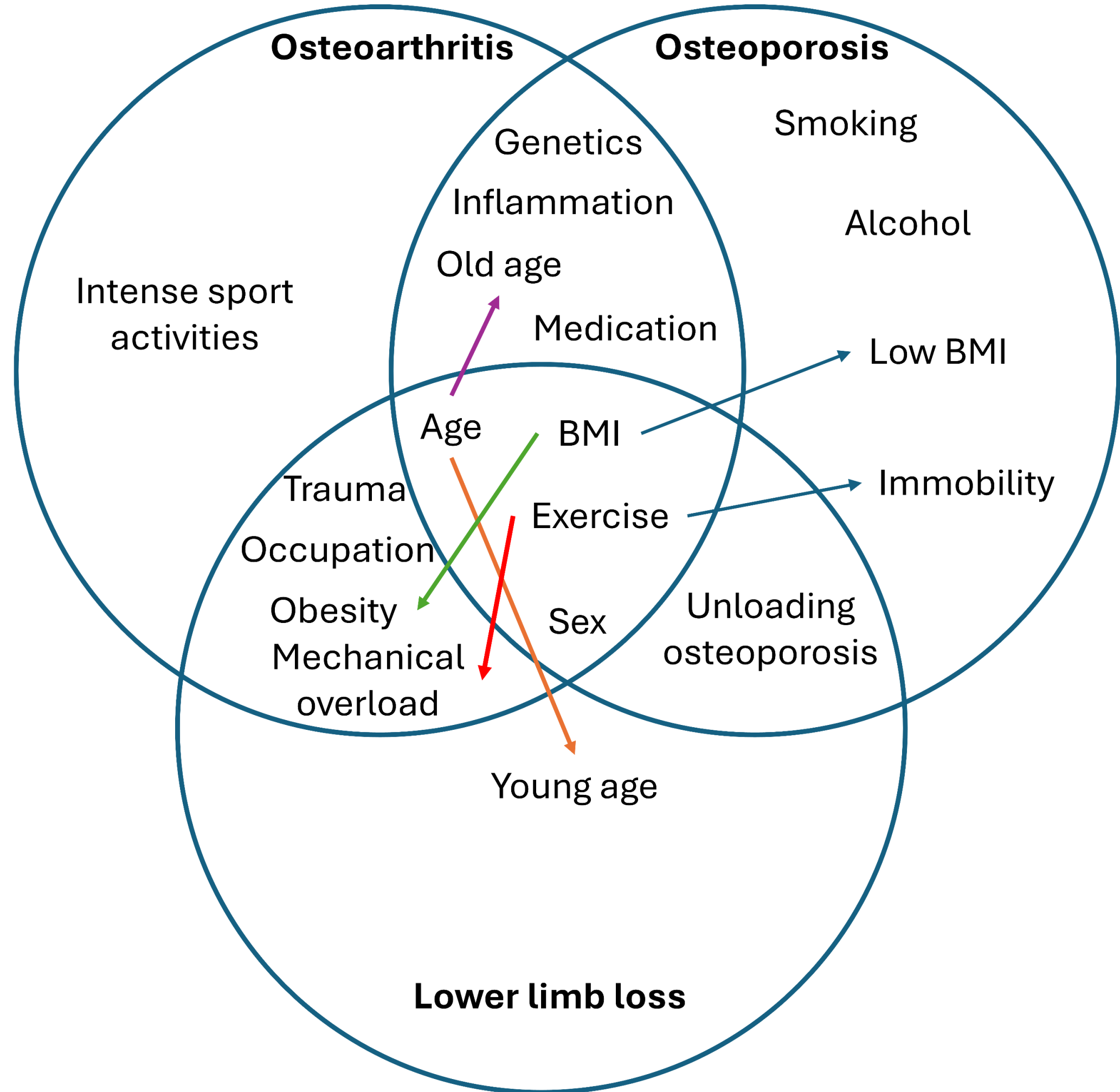


Figure 1: Convergent and divergent features of osteoarthritis, osteoporosis, and lower limb loss. Adapted from (2).

- Hypotheses**
- Femoral neck BMD, and not lumbar spine BMD, will decrease as hip OA increases on the amputation-side limb of people with lower limb loss
 - This pattern will be strongest for people with transfemoral limb loss
 - All other groups will have no relationship between BMD and OA

What is ADVANCE?
ADVANCE is a longitudinal study of long-term physical and psychosocial outcomes in 1,145 UK military personnel and veterans who served in Afghanistan. Half of the cohort sustained combat injuries and were matched to the Uninjured group at selection.

Methods
1,053 participants attended follow-up 1. Participants were split into 4 groups: Uninjured, Inj-NA, Inj-A(Int) and Inj-A(Amp) (Fig 2).
All participants had:
• Supine pelvic radiograph; Kellgren-Lawrence (KL; 0-4)
• Full-body DEXA scan; femoral neck and lumbar t-score
A mixed effects ordinal regression model for hip KL score including an interaction term between t-score and group was used, adjusted for age, socioeconomic status, BMI, smoking and time since injury or matched deployment. T-score was compared between transtibial (TT) and transfemoral (TF) amputation levels of Inj-A(Amp) for each KL score using a One-way ANOVA with Bonferroni correction.

For people with lower limb loss, a worsening femoral neck t-score is associated with worsening hip osteoarthritis

Results
The cohort was 38.1±5.4-years old and 11.4-years (IQR: 10.1-12.7) since injury or matched deployment. Adjusted marginal effects show that a 1SD increase in femoral neck t-score was associated with a 116% (OR 2.16 [1.38-3.39]), 118% (OR 2.18 [1.38-3.43]), and 198% (OR 2.98 [0.93-9.62]) increased odds for a higher KL score in the Uninjured, Inj-NA and Inj-A(Int) groups (Fig 3). A 1SD increase in t-score was associated with a 20% (OR 0.20 [0.09-0.42]) decreased odds for a higher KL score in the Inj-A(Amp) group (Fig 3). Femoral neck t-score decreased as KL scores increased for TF amputation (p=0.04), but not TT.

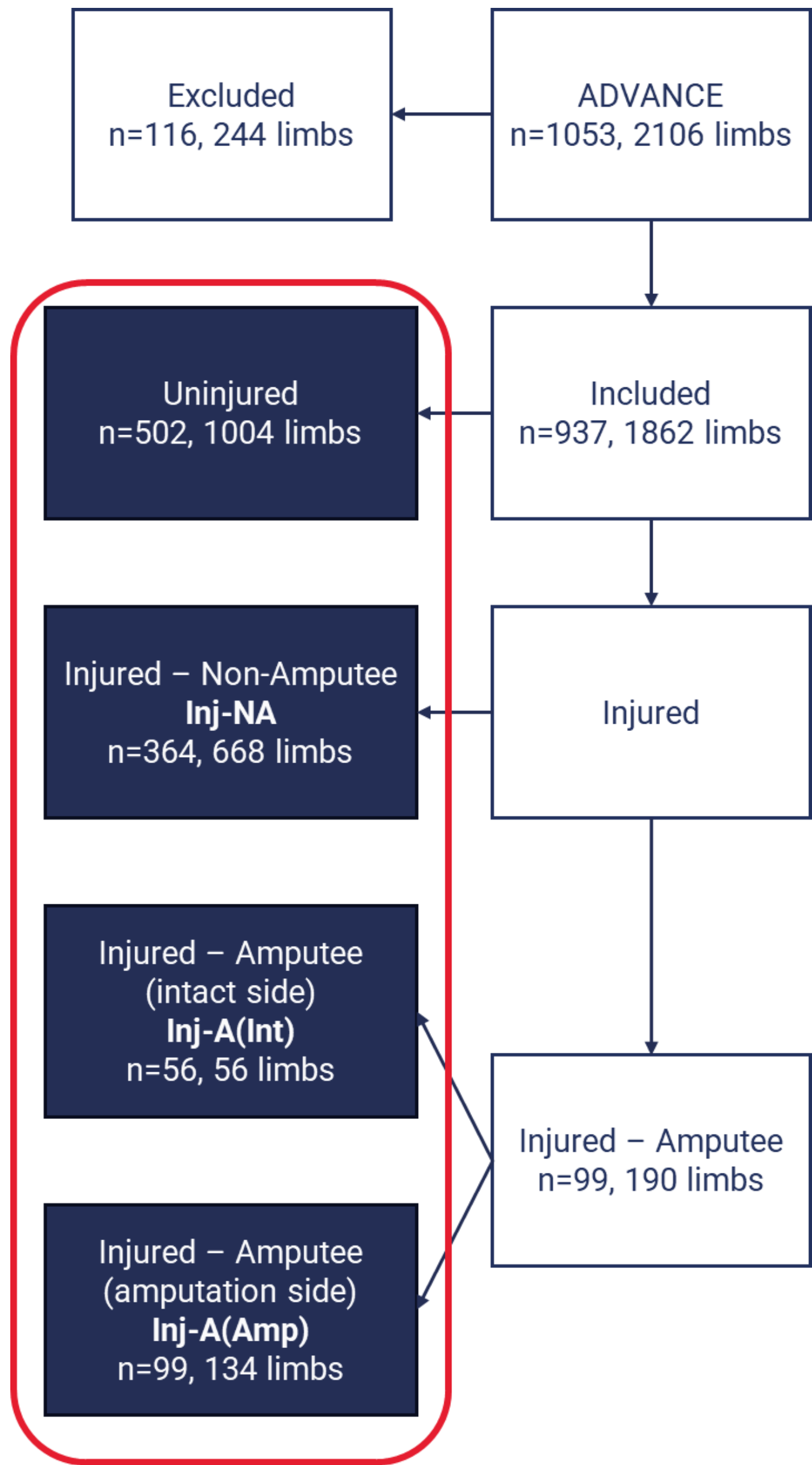
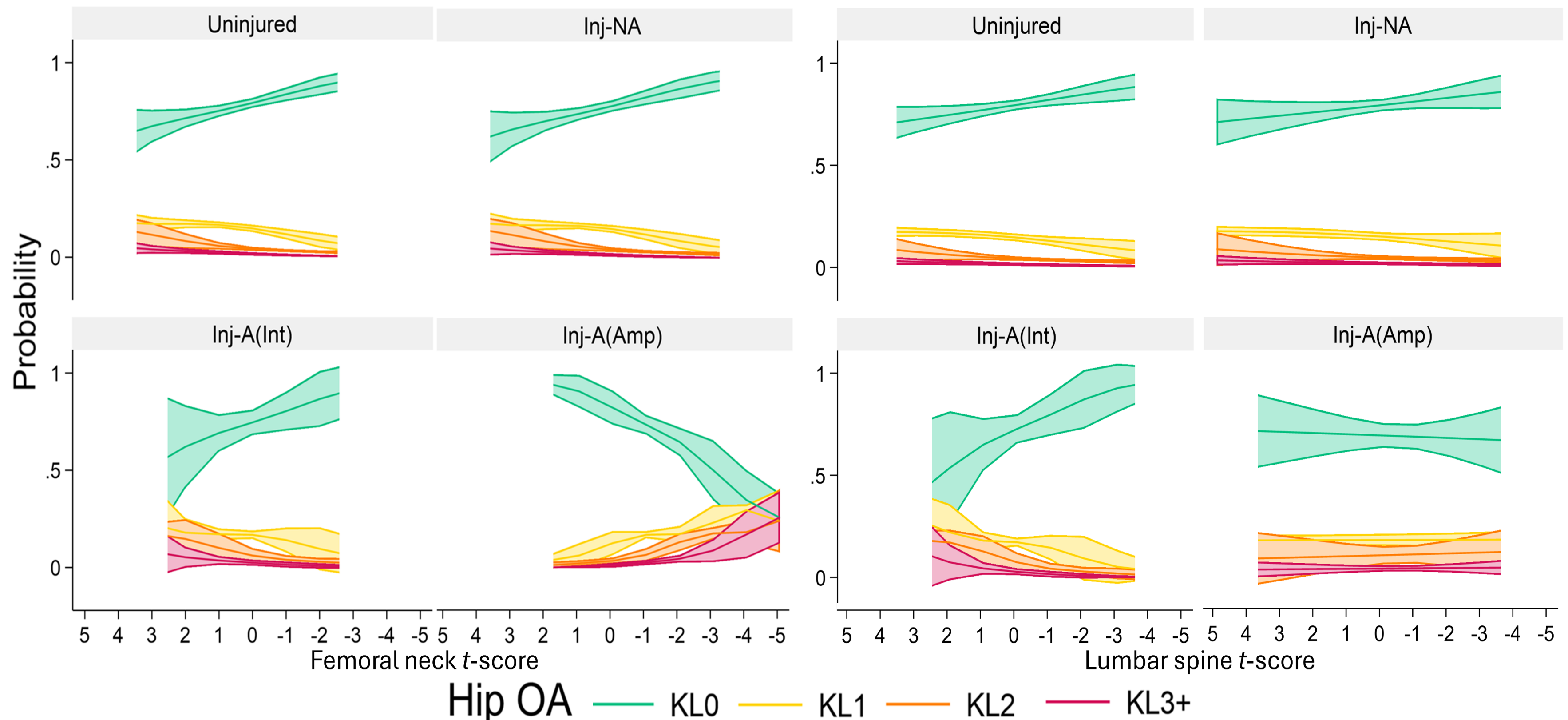


Figure 2: Number of participants and limbs who attended the ADVANCE follow-up 1, included/excluded in this analysis, and split into four groups: Uninjured, Injured-Non-amputees (Inj-NA), Injured-Amputee intact-side (Inj-A(Int)) and Injured-Amputee amputation side (Inj-A(Amp)).

Results (continued)
These patterns were not evident for lumbar spine t-score and hip OA, p=0.07 (Fig 3).
Discussion
This is the first time that these two pathologies have been investigated simultaneously in people with lower limb loss. Previous work has shown that lower limb loss increases the odds of low femoral neck BMD on the amputation-side limb by 12 times (3). Transfemoral prosthetic sockets are designed to weight bear through the ischium of the pelvis or via quasihydrostatic loading (5), which bypass the femur. Simultaneously, transfemoral limb loss increases muscle forces in amputation-side hip flexors, abductors, and adductors (6). This mechanical overloading via increased hip joint contact forces over time may increase the risk of hip OA (7). These results have important repercussions on OA and osteoporosis rehabilitation.

Conclusion
The odds of worse hip OA increases as femoral neck BMD decreases on the amputation-side limb of people with transfemoral lower limb loss. This suggests they have a unique phenotype with two distinct mechanistic pathways driving OA and low BMD separately. Careful research is required to improve conflicting treatment and rehabilitation strategies of these concomitant pathologies.

Figure 3: Margins plots for the probability of hip KL score for each t-score at the femoral neck (left) and lumbar spine (right) adjusted for age, smoking, BMI, time since injury/deployment and socioeconomic status.



References: (1) GBoDS, 2016; Lancet 388(10053): 1545-1602 (2) Bultink and Lems, 2013; Curr Rheum Rep 15(5): 328 (3) McMenemy, 2023; J Bone Miner Res 38(9): 1227-1233 (4) Watson, 2025; Osteoarthr Cartil Open 7(4): 100675 (5) Brodie, 2022; Journal of Prosthetics and Orthotics. 34(2): e73-92 (6) Benton, 2023; Front Bioeng Biotechnol, 11: 1128528 (7) Bergmann, 2001; J Biomech, 34(7): 859-71.