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Knee Sounds May Predict Osteoarthritis Severity, Symptoms and Function: Pilot Investigation Toward a Novel Dynamic Imaging System

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SESSION INFORMATION

Date: Tuesday, November 10, 2015

Session Type: ACR Poster Session C

Session Title: Osteoarthritis - Clinical Aspects Poster II: Biomarkers, Biomechanics and Health Services Research

Session Time: 9:00AM-11:00AM

Background/Purpose:

Knee sounds (KS) may provide a low-cost, risk-free means of identifying presence and severity of knee osteoarthritis (KOA). Unlike static imaging, KS during dynamic activity may correlate with symptoms and function. This study aimed to explore the association between KS, KOA severity, symptoms and function.

Methods:

Adults with clinical KOA (1986 ACR) were recruited from a UK orthopedic clinic by the attending surgeon (JC). Adults (at Imperial College London) reporting no previous knee pain >2 weeks were recruited. Knees were classified as: 1) OA, 2) healthy, 3) OA healthy (contralateral KOA). Exclusion criteria were: aged <18 years, previous surgery, unable to provide consent.

Severity of OA was assessed (single rater) using the Kellgren-Lawrence (KL) radiographic scoring method. Knee symptoms and function were assessed via self-reported Knee Injury and Osteoarthritis Outcome Scores (KOOS). KS were acquired (rate 44-48kHz) during treadmill walking (4km/h) using a contact microphone (Basik Pro, Schertler, 20Hz to 20kHz) attached to the patella, supported by a digital preamplifier (RME Babyface; PreSonus DigiMax LT).

KS features were extracted from recordings using spectro-temporal and cepstral analysis, and correlations (r) with KL and KOOS explored. Features correlating over $|r| > 0.6$ were used to train binary regression decision trees to identify KS feature-combinations predictive of KOOS. Pearson's and Bland and Altman's 95% limits of agreement (LOA) were used to assess association between predicted and true values.

Results:

Twenty-eight participants were recruited; 14 knees were excluded due to previous surgery, 42 knees were included (Table 1). OA healthy knees were excluded from KOOS. Twenty knee x-rays were available dating 10 ± 7 (all ≤ 27) weeks pre-assessment.

Of 8,141 extracted KS features, 267 exceeded $|r| > 0.6$ with KL and KOOS (Figure 1). Predicted KOOS were strongly correlated with true KOOS, except quality of life (QOL) (Figure 2); mean (95% LOA) = pain -0.8 (47.2 to -48.8); symptoms 0.2 (34.6 to -34.1), activities of daily living 0.7 (40.2 to -38.8); QOL 2.1 (67.1 to -63.0).

Conclusion:

These preliminary findings indicate that KS are predictive of OA symptoms and function, and possibly severity. Whilst encouraging, further investigation is required among a larger cohort.

TABLE 1. Demographical characteristics of study participants

	Healthy n=13	OA n=21	OA Healthy n=8
Age (years)	51.5 \pm 21.1	62.6 \pm 19.3	63.8 \pm 15.5
BMI (kg/m ²)	25.5 \pm 3.1	29.0 \pm 6.4	25.5 \pm 2.4
Females (n)	4	11	2
KOOS			
Symptoms	93.5 \pm 2.7	64.0 \pm 21.6	99.1 \pm 1.7
Pain	92.0 \pm 7.5	65.6 \pm 22.4	99.7 \pm 22.4
ADL	96.7 \pm 4.3	73.9 \pm 23.4	100.0 \pm 0.0
SP	84.0 \pm 12.8	51.4 \pm 25.7	100.0 \pm 0.0
QOL	84.7 \pm 17.8	44.9 \pm 27.5	100.0 \pm 0.0
KL* (median & range)	1 (1-1)	2 (0-4)	1 (0-2)

All numbers reported are (mean \pm standard deviation), unless otherwise stated.

OA = osteoarthritis, KOOS = Knee injury and Osteoarthritis Outcome Score, ADL = Activities Daily Living, SP = Sports and Recreational activities, QOL = Quality Of Life, KL = Kellgren-Lawrence score.

* KL are based on a subset of participants with imaging available: 2 Healthy, 10 OA and 8 OA Healthy.

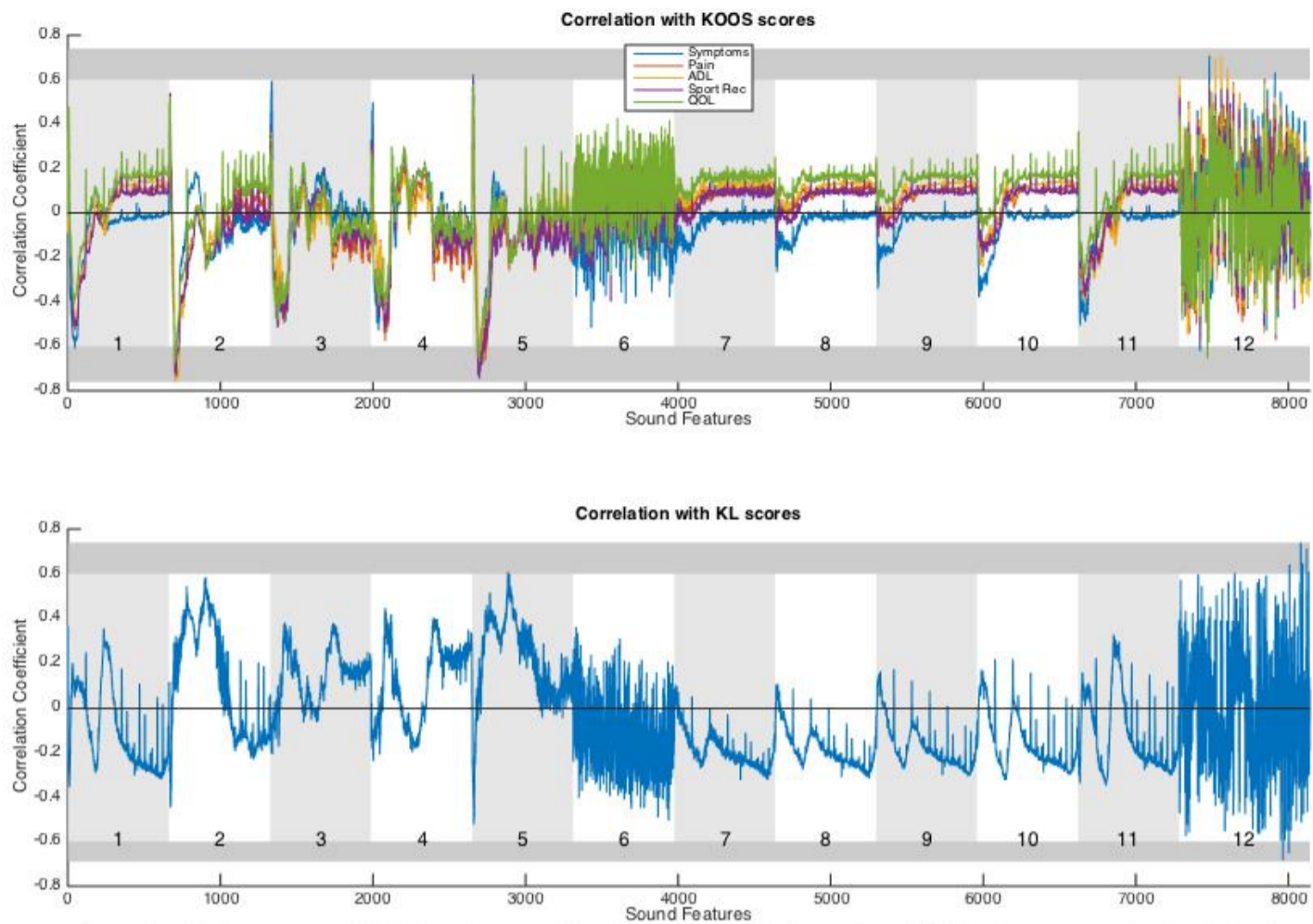


Figure 1. Correlation between $n=8141$ individual sound features and 'Knee Injury and Osteoarthritis Outcome Scores' (KOOS; colours represent sub scales; above) and 'Kellgren-Lawrence' (KL; below) scores. Numbered blocks indicate regions of $n=662$ spectrogram features at incremental frequencies explored according to: 1=Mean; 2=Variance; 3=Skewness; 4=Kurtosis; 5=Maximum; 6=Minimum; 7=10th Percentile; 8=25th Percentile; 9=50th Percentile; 10=75th Percentile; 11=90th Percentile; 12: Mel-Frequency Cepstral Coefficient (MFCC).

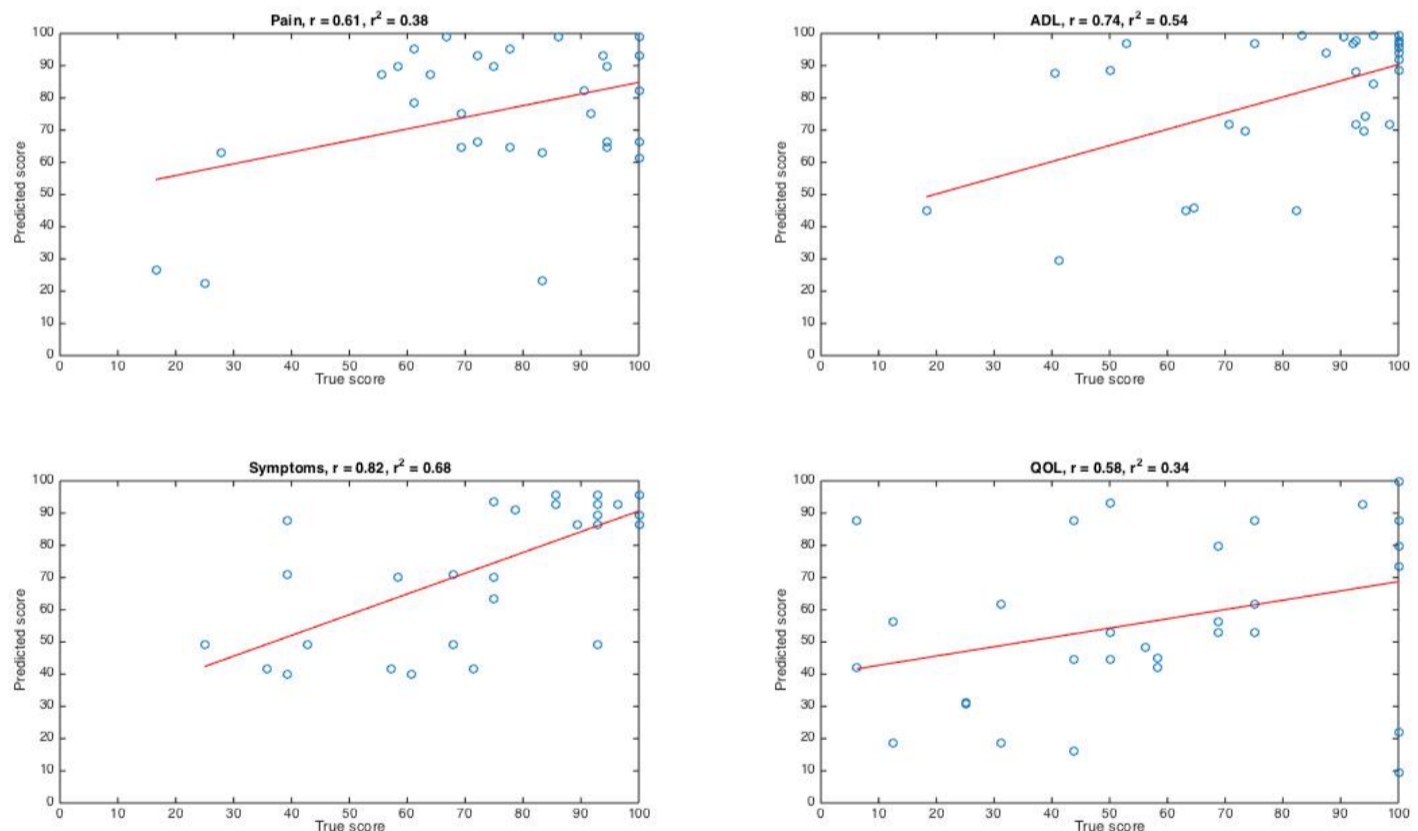


Figure 2. Correlation between true and regression tree predicted Knee Injury and Osteoarthritis Outcome Scores (KOOS) for sub scales pain, activities of daily living (ADL), symptoms and quality of life (QOL), based on a combination of $n=80, 47, 38$ and 30 knee sound features respectively.

Disclosure: V. Manning, None; C. Yiallourides, None; M. Brevadt, None; A. Moore, None; E. Auvinet, None; P. Naylor, None; J. Cobb, None.

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