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# Impaired postural balance in the morning in patients with knee osteoarthritis

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ABSTRACT

Postural balance (PB) is frequently used as an outcome measure in clinical and research settings when assessing patients with knee osteoarthritis (OA). Pain and stiffness is known to affect PB, and is elevated in the morning and evening in OA patients. The aim of this study was to explore if time-of-day affects PB control in knee OA patients.

Centre Of Pressure (COP) excursion was measured (100 Hz) by force plate technique at selected time-points (9.00 a.m., 12.30 p.m. and 4.00 p.m.) during a single day in 32 knee OA patients aged 66.0 (10.3) years. A rigorous protocol was followed to ensure comparable testing conditions across time-points. PB control was quantified by the COP variables: velocity moment ($mm^2/s$), total sway area ($mm^2$), total sway length (mm) and confidence ellipse area ($mm^2$).

A two-way mixed-effects model showed that PB significantly improved between 9.00 a.m. and 12.30 p.m. in three out of four COP variables. The observed improvement was 11.9% ($p = 0.011$) for velocity moment, 12.2% ($p = 0.011$) for total sway area and 9.4% ($p < 0.001$) for total sway length.

PB appears to be impaired in the morning relative to midday in knee OA patients. Thus, it is recommended that time of assessment is standardized between sessions when assessing PB in clinical and research settings in knee OA patients.



## 1. Introduction

Knee osteoarthritis (OA) is a prevalent disease with the potential of being disabling, and estimates are that approximately 30% of men and 33% of women with knee pain aged 60–69 years suffer from OA [1]. Postural balance (PB) measurements are widely used as outcome measures when assessing patients with knee OA in clinical and research settings. Optimal PB is vital for these patients, as their risk of falling is elevated [2]. Furthermore, patients with knee OA and decreased postural control experience proprioceptive inaccuracy and performance-based activity limitations [3].

Possible explanations for the physiological and functional impairments in knee OA patients may lie in alterations caused by the illness, as tissues within the articular cavity, ligaments, tendons and periarticular tissues are altered [4]. Also, it is well known that OA patients experience increased pain and stiffness in the affected joint, which follow a u-shaped diurnal pattern with higher levels of pain and stiffness in the morning and evening [5,6]. Finally, a decrease in the quadriceps motor neurone excitability is found in knee OA patients, which decreases voluntary quadriceps activation, thus contributing to quadriceps weakness, and diminishes proprioceptive acuity [7].

Several studies have examined PB and found that time-of-day effects on PB in healthy older adults [8], young adults [9] and sleep deprived individuals [10], but has yet to be explored in knee OA patients. On this notion, exercise intervention studies reporting balance performance (e.g. COP variables) as a primary outcome have shown inconsistent results in patients with OA [11,12]. These deviating findings may be explained by time-of-day not being controlled at baseline and follow-up assessment. Given the fact that PB is broadly assessed in clinical and research settings at many different time-points during a single day, it is relevant to investigate whether the PB of patients with knee OA is affected by the time-of-day.

This study aimed to examine if the PB fluctuated during a single day in patients with knee OA. It was hypothesized that the PB

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would be impaired in the morning and in the evening, thus, following the diurnal pattern of pain and stiffness in OA patients.

## 2. Patients and methods

### 2.1. Study population

A study population of 32 participants (19 females and 13 males, mean age (SD) of 66.0 (10.3) years) were included. They were randomly selected from 1437 patients who had been in contact with orthopaedic outpatient clinics in Frederikshavn and Farsoe, Denmark, during the period of January the 1st 2012 to June the 1st 2012. All participants had been assessed by a chief surgeon in orthopaedics. The inclusion criteria were OA in the knee joint verified radiographic by the Kellgren–Lawrence Grading Scale 2–4, not scheduled for total knee arthroplasty, and capable of understanding verbal instructions.

The exclusion criteria were: Mental illness, fractures in the lower extremities within the past 12 months, previous ipsilateral arthroplasty, neurological diseases, myocardial infarction in the past 6 months, symptoms from cerebral vascular accident, diagnosed vestibular disorders, diagnosed cancer disease and diabetes.

The allocation was carried out by identifying all the participants meeting the inclusion criteria from the automatically computer generated list of 1437 patients. A total of 32 participants were included by calling them in a random order on the basis of a computer-produced sequence of numbers. All participants were informed that they could withdraw their consent of participation at any time.

Use of medicine, which is known to have adverse effects, i.e. dizziness or other vestibular disturbances, was taken into account by investigating the frequency and severity of these effects. Specifically, this was done by interviewing all the participants, asking about their experience of adverse effects related to their individual use of medicine. None of the participants reported that they were influenced by adverse effects affecting their PB. Thus, the use of medicine known to have adverse effects affecting PB was not a reason for exclusion. As visual impairment is also known to affect balance, participants were allowed to use vision correction aids if they had impaired eyesight and thus, this was not a reason for exclusion. The study was approved by the Danish Data Protection Agency and conducted in accordance with the Declaration of Helsinki. On the day of testing, written informed consent was obtained from all the participants on forms approved by the local Ethics Committee of The North Denmark Region.

### 2.2. Demographic information

Participants were invited by telephone and if they agreed to take part in the study, a letter was sent to them. The letter contained questionnaires concerning medicine with regards to type and amount, prior diagnoses, sleep per night, the five dimension EuroQol Group questionnaire EQ-5D-3L, visual analogue scale (VAS, pain intensity measured on a 10 cm VAS with terminal descriptors of "no pain" to "worst pain possible") and the Knee Injury and Osteoarthritis Outcome Score (KOOS) with scores ranging from 0 (worst) to 100 (best) (Table 1). On the day of examination the height and weight of the participants were assessed.

### 2.3. Assessment of postural balance

PB was measured using centre of pressure (COP) excursions recorded at a frequency of 100 Hz using an instrumented force plate (Good Balance, Metitur, Finland) in a narrow standing position with the heels and toes together. The sampling rate of 100 Hz was chosen as this is the most used in association with standing balance measurements and as the fluctuations of the body are slow compared to e.g. a counter-movement jump. Measurements were performed at 9.00 a.m., 12.30 p.m. and 4.00 p.m. ±30 min on a single day for each participant, all measurements being performed in the period of 25th of June to 24th of July 2012.

**Table 1**
Demographics.

| Demographic variable | |
|---|---|
| Age (years) | 66.0 (10.3) |
| Gender (women/men) | 19/13 |
| Height (m) | 1.70 (0.09) |
| Body mass index (kg/m$^2$) | 28.3 (4.9) |
| Kellgren & Lawrence grade (arbitrary unit) | 2.3 (0.4) |
| Number of participants with K & L grade | |
| 2 | 24 |
| 3 | 8 |
| 4 | 0 |
| VAS peak pain in previous 24 h (cm) | 3.4 (2.4) |
| KOOS score (arbitrary unit) | 60.5 (18.2) |
| Symptoms | 64.6 (20.3) |
| Pain | 63.7 (20.5) |
| Function, daily living | 69.4 (18.7) |
| Function, sports and recreational activities | 39.2 (25.4) |
| Quality of life | 45.5 (21.5) |

Demographics of participants in fractions or mean with SD presented within parenthesis ($n = 32$).

At each time-point three recordings of 30 s were performed, and 30 s of rest was allowed between each recording. Participants were asked to remove their shoes prior to all force plate recordings and told to remain in a standing position without moving, with their arms folded across the chest while focusing their sight on a visual target positioned 3 m away while being tested. This position was chosen as it has been used in a previous study [8]. A piece of tape was placed on the force plate to ensure a standardized foot placement for each participant, as this variable has proven important for the validity of the collected data [13]. The temperature, noise level, light intensity and humidity in the test room were kept constant during testing. On the day of testing participants were asked not to exercise, perform heavy work and until 1½ h prior to each testing time-point, consume food or beverages, other than water. All participants were encouraged to leave the hospital between measurements to make the day similar to their everyday life, e.g. grocery shopping or simply having a rest.

The outcome measures of the study were COP excursion distance expressed as velocity-moment (mm$^2$/s), total sway area (mm$^2$), total sway length (mm), and confidence ellipse area (mm$^2$). This category of measures was chosen as they previously have shown to be useful in measuring PB in patients with knee OA [14]. Methodological details on the calculation of velocity-moment, confidence ellipse area and total sway area have been reported elsewhere [15,16]. A high intra-session reliability (intraclass correlation coefficient (ICC) > 0.85) has previously been reported for total sway length and sway area, respectively [15]. Also moderate-to-high test-retest reliability (ICC = 0.75) for confidence ellipse area [17], and for the velocity moment parameter (ICC = 0.96) [18] has been reported. Based on the ICC measurements and the fact that a previous study did not find any signs of a learning effect in similar measurements between 9.00 a.m. and 12.30 p.m. [8], our choice of method was justifiable. Like other studies using force plate analysis on similar participants, practice on the force plate prior to testing was not performed [14].

The analogue signal from the force plate was sent through an amplifier and subsequently converted to a digital signal using a 24-bit, three channel A/D converter before being transferred to a Personal Computer through a Bluetooth connection. The signal was