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DISABILITY AND REHABILITATION
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RESEARCH ARTICLE

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Cardiometabolic disease risk in relation to objectively measured physical activity, sedentary behaviour in South African adults with knee and hip osteoarthritis

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ABSTRACT

Purpose: This study aimed to investigate the relationship between cardiometabolic disease risk and time spent in device-measured activity behaviours in a cohort of people with advanced osteoarthritis (OA) awaiting joint replacement surgery.

Materials and methods: Cardiometabolic risk biomarkers were assessed in people with OA ($n=96$; hip $n=38$, knee $n=58$; mean (SD) age = 64.3 (9.8) years; 71% female). Physical activity (PA) and sedentary behaviour (SB) were measured by accelerometer over seven days (24 h/day).

Results: There were similar patterns of PA and SB between the hip and knee OA participants except for total number of steps (hip = 3365 (2926) vs knee 4344 (2836) steps/day; $p=0.018$) and total stepping time (hip = 50.8 (38.2) vs knee = 67.2 (38.5) min/day; $p=0.005$). Each additional cardiometabolic risk factor accumulated was associated with a 26.3 min/day increase in sedentary behaviour ($p=0.032$; 95% CI: 2.3, 50.2), a 26.3 min/day decrease in upright time ($p=0.032$; −50.2, −2.3) and a 23.6 min/day decrease in standing time ($p=0.032$; −45.1, −2.1).

Conclusions: In people with hip or knee OA, increased cardiometabolic disease risk was associated with more sitting and less upright and standing time. Findings support targeting reductions in sedentary behaviour for improvements in cardiometabolic health in people with osteoarthritis.

IMPLICATIONS FOR REHABILITATION

- Knee and hip osteoarthritis is a condition which is associated with an increased risk of cardiometabolic disease but also due to the low levels of physical activity and high levels of sedentary behaviour.
- Offsetting sedentary behaviour with light physical activity offers a feasible interventional target to reduce the risk of cardiometabolic disease in people with hip and knee osteoarthritis.

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KEYWORDS
Knee; hip; osteoarthritis; physical activity; sedentary behaviour; accelerometer

Introduction

Osteoarthritis (OA) is one of the most common joint disorders in older adults [1]. The prevalence of OA is increasing with an estimated global incidence rate of 130 million adults with the condition [2]. It is estimated that about 40 million people will experience severe functional impairments by the year 2050 [3]. While a recent meta-analysis estimated the global prevalence and incidence of OA to be 16% and 203 per 10 000 person-years respectively, there were no data from Sub-Saharan Africa included, except for one study from North Africa [4]. In addition to the lack of OA data registries in Africa, the meta-analysis considered prevalence studies in the last two decades [4], thus excluding potential studies from Africa [5]. These observations highlight the paucity of reliable data to reflect current disease trends in Africa [4,5].

A more recent meta-analysis revealed that the prevalence of OA in low- and lower-middle-income countries is 16.1%, with a prevalence of 14.2% in Sub-Saharan Africa [6]; however, this review did not include upper-middle-income countries such as South Africa [7]. The World Health Organisation Study on global ageing and adult health (SAGE) revealed a high prevalence of arthritis (i.e., 19.9% of women and 14.1% of men) in low-to middle-income countries with the prevalence of 9.5% in South Africa [8]. Findings from the Global Burden of Disease Study 2019 also showed that the prevalent cases of OA in Southern Africa increased from 1 760 000 in 1990 to 3 850 000 in 2019 with corresponding age-standardized prevalence rates of 6 250 per 100 000 and 6 540 per 100 000 persons respectively [9]. However, these estimates were based on very few, old (>30 years) epidemiological studies when South Africa was under apartheid

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[10–12] and the profile of the patients may not reflect the current OA population [5], highlighting a need for research in this area. Although there are few accurate data available [13], surgical waiting times for joint replacement in South African public hospitals are also significantly long [14], compounding the burden of this condition.

In addition to a reduction in physical function and quality of life [15,16], OA is associated with decreased physical activity (PA) [17,18] and an increased time spent in sedentary behaviour (SB) [19]. The WHO physical activity guidelines recommend that middle aged and older adults should perform 150–300 min of moderate intensity or 75–150 min of vigorous intensity PA or a combination of both per week [20]. A systematic review on objectively measured PA in people with OA reported that as little as 13% of this population meet these guidelines [21]. Studies have also reported levels of SB between 8.8 and 11.5 h during the waking day in people with OA [19,22,23] and the amount of SB does not change significantly following primary joint replacement surgery [24–26]. Reported barriers to engaging in sufficient PA for people with OA, including those waiting for joint replacement surgery, are partly due to symptoms of pain and reduced loss of joint mobility associated with the condition [27,28]. Accelerometers are a valid method for the measurement of activity behaviours such as PA of varying intensity, bouts, duration and step counts in a free-living environment [29,30]. These devices measure accelerations of body movements and also capture the frequency, intensity and duration of movement in a time-stamped manner [31]. The advent of body-worn PA devices to objectively assess combinations of activity behaviours has enabled the determination of important associations with health-related outcomes [32]. However, self-reported symptoms of pain and dysfunction do not appear to be a predictor of device-measured activity behaviours in people with OA awaiting total joint replacement surgery [33–35] but rather factors such as habits and motivation to engage in exercise, as well as heterogeneity in patients, activity monitors and methods across studies may explain the lack of association [21].

The use of physical activity interventions to manage the symptoms of OA while waiting for joint replacement surgery is a simple and cost-effective method that has major implications in settings like those in South Africa. The under-resourced public health sector in South Africa services 84% of the population, many of whom cannot afford health insurance [36]. The result of an overburdened public healthcare sector in terms of OA care, means long waiting times for people requiring joint replacement surgeries and thus a prolonged time spent living with a degenerative condition which significantly impacts activities of daily living [14] and increases risk factors for comorbidities such as cardiometabolic diseases [2]. Inequities in healthcare access across the African continent and the severe inability for people to obtain appropriate health treatment [37] makes research into activity behaviours and OA-related health outcomes an essential area for research.

The implication of low levels of PA and high levels of SB is that they are also associated with poor cardiovascular fitness and an increased risk of cardiovascular and metabolic disease morbidity and mortality [38–40]. OA itself is a significant risk factor for cardiovascular events such as heart failure and ischaemic heart disease [41–43], and people with OA have increased metabolic risk factor profiles [44]. The presence of comorbidities in people with OA is associated with a lack of self-reported physical activity [45] and device- measured light and moderate-to-vigorous PA are shown to be inversely associated with metabolic syndrome among older adults with OA [46], however it is unclear in this population what the relationship between PA, SB and cardiometabolic risk is.

To our knowledge, no studies have examined the associations between objectively or device-measured activity behaviours and the risk of cardiometabolic disease in people with OA awaiting surgery in South Africa. This study aimed to investigate the relationship between cardiometabolic disease risk and the time spent in device-measured activity behaviours in a cohort of people with advanced OA awaiting joint replacement surgery.

Materials and methods

Study design

This was a cross-sectional study of a cohort of people living with symptomatic knee OA or hip OA on the waiting list for total joint replacement surgery.

Participants

The study took place at a public Academic Hospital, located in a major city in South Africa. People with moderate to severe hip or knee OA, who were scheduled for joint replacement surgery in the orthopaedic department of the hospital between May 2018 and January 2020 were screened for eligibility. As and when patients attended their scheduled clinic appointment with their surgeon at least two weeks prior to their surgery, they were screened for initial eligibility by the attending surgeon, and study information and contact details of the researchers were provided. Volunteers were then further screened for inclusion by the researchers using a generic medical history screening health questionnaire and if eligible, invited to participate in the study. Participants included men and women between the ages of 45 and 85 years old, diagnosed by the attending orthopaedic surgeon with primary hip or knee OA. People were also included in the study if they were scheduled for primary, unilateral total joint replacement surgery, and if they were ambulant, with or without assistive devices. People were excluded if they were wheel-chair bound or had other co-morbidities such as debilitating stroke, rheumatoid arthritis and neurological movement disorders, that could affect their participation in PA. The study was approved by the Human Research Ethics Committee of the University of the Witwatersrand (clearance certificate number: M180587). Written informed consent was obtained from all participants prior to participation in the study.

Activity behaviours

Physical activity and SB were assessed for each participant with an activPAL micro 4 accelerometer (PAL Technologies, Glasgow, Scotland). The activPAL is a triaxial accelerometer which is a small and lightweight device (similar size to a wristwatch face). The devices were charged before being placed on the participant, and have a minimum of 14 day battery life. The activPAL was fitted at the hospital visit, and taped with a non-irritant, transparent, waterproof taping to the participant's anterior thigh, on the same side as the OA-affected joint. Participants were asked to wear the activPAL for 24 h/day for seven days, and to return the accelerometer on their next hospital visit. Since the activPAL was covered with waterproof taping there was no need to remove the device when showering, bathing or swimming. The activPAL commercial software (PALanalysis) was used to download and process the individual data and extract the activity behaviours of interest. The software summarised the duration of time spent in activity behaviour outcomes of interest as the daily average over the

number of valid days. Because the activPAL remained taped to each participant's thigh for 24 h a day, there was no need to remove non-wear time. Sleep was identified by the automated software algorithm and removed from the total wear time after confirmation with each participant's self-reported sleep log. What remained was the awake wear time for each day the activPAL was worn. A valid day was classified as 10 h of continuous wear and each participant was required to have a minimum of 4 valid days for their data to be used in the final analysis [47]. The activity behaviour outcomes of interest from the valid day data were average daily step count, time spent in different postures or transitioning between postures, as well as time spent in bouts of sitting and stepping. The total times spent in each activity were also reported as a proportion of awake wear time.

Self-reported joint functional outcomes

The Knee injury and Osteoarthritis Outcome Score (KOOS) and the Hip dysfunction and Osteoarthritis Outcome Score (HOOS) were self-administered and used to assess patient-perceived joint injury and dysfunction in five domains including symptoms and stiffness, pain, activities of daily living (ADL), sport and recreational activity, and quality of life (QoL). Using a Likert scale, all items have five possible answers from 0 to 4, with 0 representing no joint problems and 4 representing extreme joint problems [48]. In interpreting the hip and knee score in this study, scores were transformed on a 0–100 scale, where a score of zero indicates poor joint functional outcomes and a score of 100 indicates no joint dysfunction [49].

Risk factors for cardiometabolic disease

Risk factors for cardiometabolic disease were collected from available measurements of body mass index and plasma levels of total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides, and random glucose in blood samples collected from each participant. Height and weight were measured to the nearest millimetre and gram respectively using a stadiometer (Seca, model 202 UK) and a calibrated electronic scale (Dismed, USA). To obtain the risk factors from plasma biomarkers, one finger from each participant was decontaminated with an alcohol swab and a sterilised lancet was used to puncture the tip of the finger. Approximately 15–40µL of blood was collected using a micro-pipette. The concentrations of the bio-markers in the samples were measured using a diagnostic point-of-care analyser (Cardio-Chek PA; Polymer Technology Systems Inc., Indianapolis, IN, US). The analyser is validated for measuring cholesterol, triglycerides and glucose [50]. Participants were deemed as having a risk factor for cardiometabolic disease if they met the criteria for risk for each of the seven cardio-metabolic markers (Table 1). The total number of risk factors was determined for each participant.

Table 1. Risk factor criteria to classify people at risk for cardiometabolic disease.

Criteria	Threshold for risk
Total cholesterol (mmol.l^{-1})	>5
HDL (mmol.l^{-1})	<1
LDL (mmol.l^{-1})	>3
Non–HDL (mmol.l^{-1})	>3.9
Triglycerides (mmol.l^{-1})	>2.3
Random glucose (mmol.l^{-1})	>7.8
BMI (kg.m^{-2})	>24.9

HDL: High density lipoprotein; LDL: Low density lipoprotein; BMI: body mass index.

Statistical analysis

Data are presented as means and standard deviation (SD) unless otherwise stated. Data were assessed for normality using a Shapiro-Wilks test. Participant characteristics and cardiometabolic markers were compared between people with hip and knee OA using an unpaired t-test. Functional outcome scores were compared between people with hip and knee OA using a Wilcoxon rank-sum test (nonparametric data). Accelerometer measured activity behaviours were compared between hip and knee OA participants using analysis of covariance (ANCOVA) adjusting for awake wear time. Linear regression was used to determine the predicted change in activity behaviours with each increase in the number of cardiometabolic risk factors that participants accumulated. Data for these analyses were combined for participants with hip and knee OA and adjusted for awake wear time. Two participants recorded much higher stepping intensity data and were considered outliers. Therefore analyses were conducted with and without these two data points. The analyses including these two participants are summarised in the supplementary material. Data were analysed using StataIC (Version 15.1, StataCorp LLC, TX, USA). Statistical significance was set at $p < 0.05$.

Results

Results are reported according to the STROBE guidelines for the reporting of cross-sectional studies [51]. A total of 136 people with moderate to severe OA volunteered to participate in the study (Figure 1, hip OA, $n = 53$, knee OA, $n = 83$). Of those 136 volunteers, 96 participants (hip OA $n = 38$; knee OA $n = 58$) were included in the data analysis. Reasons for participants being excluded from the study are reported in Figure 1.

Table 2 summarises the participant characteristics, functional outcome scores and the number of cardiometabolic risk factors in participants with hip and knee OA. Participants in both hip and knee OA groups were mostly female, older adults and were categorised as being Class I obese. Although people with knee OA reported better functional outcome scores than people with hip OA (not significant), both people with hip and knee OA reported HOOS and KOOS scores below the median score of 50 for all subscales. The majority (85%) of participants had more than two risk factors for cardiometabolic disease (Table 2).

Overall participants spent on average more than 8 h per day sitting and 1 h stepping per day (Table 3). Overall the participants accumulated less than 5000 steps per day and spent fewer than 5 min per day stepping at an intensity that is considered moderate (cadence >100 steps per minute) [52]. Of the total time spent sitting, more than half of that time (4.5 h) was accumulated in bouts of sitting lasting longer than 30 min, while approximately 31% of the total time spent sitting (2.5 h) was accumulated in bouts lasting longer than 60 min. After adjusting for awake wear time, participants with knee OA took more steps per day ($p = 0.018$), spent approximately 17 min more time stepping per day ($p = 0.005$) and spent a greater proportion of their awake wear time stepping ($p = 0.023$) compared to those participants with hip OA (Table 3). There were no other differences in activity behaviours between participants with hip or knee OA.

After adjusting for awake wear time, each additional cardiometabolic risk factor accumulated was associated with an increase in sitting time by 26.3 min per day ($p = 0.032$). Each increase in the number of cardiometabolic risk factors was associated with a reduction in upright time of approximately 26 min per day ($p = 0.032$) and a reduction in standing time by approximately 23 min per day ($p = 0.032$). There were no other significant

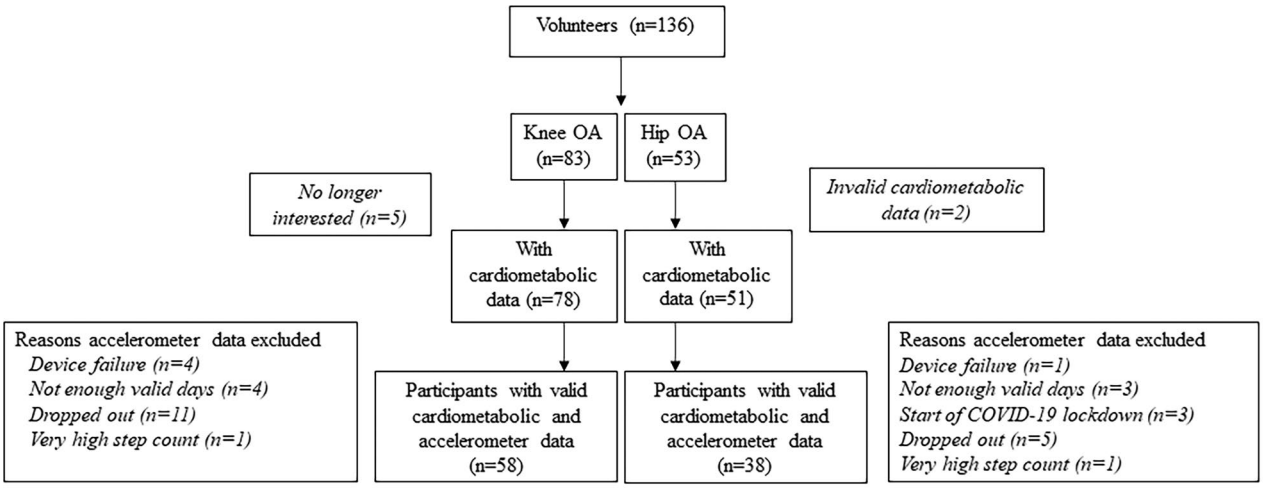

Figure 1. Flow diagram of the number of initial participants recruited and participants included in final data analysis.

Table 2. Characteristics of participants included in analysis.

	Total ($n = 96$)	Hip ($n = 38$)	Knee ($n = 58$)	p-value
Age (years)	64.3 (9.8)	62.3 (9.6)	65.5 (9.7)	0.118
Female (n, %)	71 (74)	26 (68)	45 (78)	–
Weight (kg)	88.7 (17.3)	87.4 (18.5)	89.5 (16.6)	0.562
Height (m)	1.62 (0.09)	1.63 (0.08)	1.60 (0.09)	0.308
BMI (kg.m^{-2})	33.9 (6.3)	33.0 (6.5)	34.6 (6.2)	0.221
Total cholesterol (mmol.l^{-1})	4.0 (0.9)	4.2 (1.0)	3.9 (0.9)	0.149
HDL (mmol.l^{-1})	1.3 (0.3)	1.3 (0.4)	1.3 (0.3)	0.980
Triglycerides (mmol.l^{-1})	1.8 (0.9)	1.8 (0.8)	1.9 (1.0)	0.536
Random glucose (mmol.l^{-1})	7.0 (1.7)	6.9 (2.0)	7.0 (1.4)	0.674
LDL (mmol.l^{-1})	1.9 (0.8)	2.1 (0.8)	1.8 (0.8)	0.149
Total Cholesterol/HDL (mmol.l^{-1})	3.2 (0.9)	3.5 (1.0)	3.1 (0.9)	0.041
HOOS/KOOS subscale scores				
Symptoms	–	25 (15–50)	35.7 (21.4–50.0)	0.183
Pain	–	22.5 (10–42.5)	33.3 (16.6–44.4)	0.078
ADL	–	23.5 (10.3–38.2)	32.4 (20.6–45.6)	0.056
Sport and Rec	–	0 (0–6.3)	0 (0–20)	0.696
QoL	–	9.4 (0–25)	18.8 (6.3–31.3)	0.099
Smoke (n, %)	8 (8)	4 (10)	4 (7)	–
Risk factors				
0	2 (2.1)	1 (2.6)	1 (1.7)	–
1	12 (12.5)	6 (15.8)	6 (10.3)	–
2 or more	82 (85.4)	31 (81.5)	51 (87.9)	–

Data are mean (SD) except for female, smoke, and risk factors which are n (%). HOOS/KOOS subscale scores are median (IQR). A subscale score of 0 means extreme problems while a score of 100 means no problems. HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein; ADL: activities of daily living; QoL: quality of life. Blood variables are adjusted for age and BMI. *Chi-square $\chi 2 = 0.7917$.

associations between the number of cardiometabolic risk factors accumulated and accelerometer measured activity behaviours (Table 4).

Discussion

This study aimed to determine the relationship between cardiometabolic disease risk and time spent in device-measured activity behaviours in a cohort of participants with hip and knee OA awaiting joint replacement surgery. We found that an increase in the number of cardiometabolic risk factors that participants accumulated was associated with more time sitting, less time spent in an upright position and in particular less time standing. There was no association between stepping activity (i.e., physical activity) and cardiometabolic disease risk, however the results from our study are supported by research in healthy adults that has shown that high amounts of time spent in SB is a major risk factor for premature mortality, heart disease, cancer, diabetes and obesity [38,39]. The results from our study suggest that a reduction in the time spent in sedentary behaviour and a higher amount of time in upright positions may have benefits for cardiometabolic health in people with OA and warrants further investigation in a controlled trial.

Overall, people in this study sat on average for over 8 h per day, which was equivalent to 55% of their waking time spent in SB. Both OA groups spent similar amounts of time (over four hours) in sedentary behaviour that was accumulated in bouts of 30 min or more. The volumes of SB seen in this study are similar to other studies that have measured activity behaviours using accelerometers in similar aged cohorts. Such studies report people with knee OA spending between 8 and 12 h of their awake time in SB [19,22–24]. However, other studies carried out in participants with hip and knee OA have reported higher stepping times [53] and less time spent in SB [54] compared to the participants in our study. In the latter studies the authors excluded people with OA waiting for joint replacement surgery and therefore their participants most likely had better physical function.

Table 3. Device-measured activity behaviours of people with hip and knee OA.

	Total ($n=96$)	Hip ($n=38$)	Knee ($n=58$)	p value
Awake wear time (min/day)	857.0 (116.4)	877.3 (77.5)	843.8 (135.0)	0.169
Number of valid days (n)	5.9 (0.4)	5.9 (0.4)	5.9 (0.5)	0.865
Sitting time (min/day)	499.9 (146.4)	526.9 (150.0)	482.2 (142.5)	0.281
Sitting time (% awake wear time)	58.7 (16.3)	59.9 (15.7)	57.9 (16.8)	0.571
Time in sitting bouts >30 min (min/day)	270.7 (140.2)	295.1 (139.2)	254.7 (139.7)	0.156
Time in sitting bouts >60 min (min/day)	155.7 (129.7)	177.2 (130.0)	141.6 (128.7)	0.142
Sit to stand transitions (n/day)	43 (19)	43 (23)	43 (15)	0.510
Upright time (min/day)	357.2 (155.0)	350.4 (134.6)	361.7 (168.1)	0.281
Upright time (% awake wear time)	41.3 (16.3)	40.1 (15.7)	42.1 (16.8)	0.571
Standing time (min/day)	296.5 (135.6)	299.6 (126.0)	294.5 (142.5)	0.689
Standing time (% awake wear time)	34.3 (14.5)	34.4 (14.7)	34.3 (14.6)	0.986
Total steps (n/day)	3957 (2896)	3365 (2926)	4344 (2836)	0.018
Stepping time (min/day)	60.7 (39.0)	50.8 (38.2)	67.2 (38.5)	0.005
Stepping time (% awake wear time)	7.0 (4.2)	5.8 (4.2)	7.7 (4.1)	0.023
Stepping time at cadence > 100 (min/day)	2.2 (4.9)	2.8 (5.6)	1.7 (4.4)	0.366

Data are unadjusted means (SD). p value for differences between hip and knee OA groups, adjusted for awake wear time.

Table 4. Univariate linear regression models for estimated change in activity behaviours with an increase in the number of cardiometabolic risk factors.

	Model R^2	Coefficient	SE	95% CI	t value	p value
Total steps (n/day)	0.2053	−182	232	−642, 279	−0.78	0.436
Sitting time (min/day)	0.1462	26.3	12.1	2.3, 50.2	2.17	0.032
Time in sitting bouts >30 min (min/day)	0.0099	11.6	12.5	−13.1, 36.4	0.93	0.353
Time in sitting bouts >60 min (min/day)	0.0200	11.2	11.5	−11.6, 33.9	0.97	0.333
Sit to stand transitions (n/day)	0.1345	1.9	1.6	−1.2, 5.0	1.20	0.234
Upright time (min/day)	0.2389	−26.3	12.1	−50.2, −2.3	−2.17	0.032
Standing time (min/day)	0.2002	−23.6	10.8	−45.1, −2.1	−2.18	0.032
Stepping time (min/day)	0.2290	−2.7	3.1	−8.8,3.4	−0.87	0.386
Stepping time at cadence > 100 (min/day)	0.0210	0.3	0.4	−0.6,1.2	0.69	0.491

All outcomes were adjusted for awake wear time. Total steps and Stepping time were additionally adjusted for joint.

People with knee OA took more steps per day and spent more time stepping compared to people with hip OA. Although it wasn't significant, a possible reason for this is that the knee OA group showed a trend of having better scores in the subscales of activities of daily living and pain compared to those with hip OA as measured with the functional (HOOS and KOOS) questionnaires. Nevertheless, people with OA in our study would also be considered to be physically inactive. Stepping at a cadence of more than 100 steps per minute, which is an estimate of moderate intensity activity [55], was only performed on average for a total of approximately 15 min per week. A minimum activity target of 45 min/week of moderate to vigorous activity has been suggested for people with OA to improve physical function [56], however participants in our study were unable to achieve half of that volume, again most likely due to the fact that our participants were on the surgical waiting list for joint replacement and were affected by pain and functional limitations. The amount of time spent stepping at a cadence >100 steps per minute was not associated with cardiometabolic risk and this may be most likely due to the low number of participants in this study who engaged in this level of activity. In addition, we used an estimate of moderate intensity activity however it is challenging to characterise stepping cadences with the activPAL at slow and fast walking speeds [57]. Nevertheless it would be worth investigating associations between stepping cadence at higher intensities and cardiometabolic disease risk in people with less advanced OA.

By 2060, the demand for hip and knee joint replacement in the UK is estimated to increase by 40% [58]. In low income countries, there are often not adequate resources to offer joint replacements to all patients who meet the criteria, and waiting times for surgery can be years [13], exacerbating the pain and limitations experienced by people with OA. The time spent waiting for joint replacement surgery may serve as an opportunity to implement cost-effective rehabilitative strategies for the management of the symptoms of OA and risk of comorbidities. Exercise therapy has the potential to delay the need for hip replacement surgery [59], however considering that such a small proportion of people with OA engage in sufficient PA, and the fact that significant associations were only found between cardiometabolic health and activities at the lower end of the spectrum (sitting and standing but not stepping), the findings of our study suggest that perhaps targeting lower intensity activities and regularly breaking up SB could be investigated as feasible targets to improve cardiometabolic health through engagement in physical activity in people with OA. Taking regular breaks in prolonged sitting has been shown to benefit various markers of cardiovascular disease [60], and may be a target for prevention and management of comorbidities in people with OA [61,62]. Of note in our study, sit to stand transitions (STS) were not associated with cardiometabolic disease risk again indicating a need to delineate between bouts of light activity/stepping intensity. We have previously suggested targeting increases in light intensity activity in participants with knee OA who have undergone total knee replacement as following surgery there appeared to be a reduction in SB and an increase in light intensity activity only [24]. As an intervention, reducing sedentary behaviour could also be a more attractive than increasing physical activity levels in patients with pain and limited function (such as in osteoarthritis). This is important in a country such as South Africa for a population of people underserved by a healthcare system, and patient management could consider shifting from predominantly hospital-based to a more self-management model of care.

The study is limited in that it was a cross-sectional study and therefore we cannot determine causality. Due to being limited in the different risk factors that we could obtain for determining cardiometabolic disease risk, we were unable to measure waist circumference or obtain a history of blood pressure which are strong risk factors for the aetiology of CVD and therefore did not differentiate between cardiovascular disease and metabolic disease risk. However, we would anticipate similar findings to those in

our study and those of previous studies for people with hip and knee OA [41–44]. The limitations of the current study also include the high dropout rate. To extend the findings of this study, further research should be done to determine the additional risk that people with OA have for cardiometabolic disease over and above a healthy population in the context of current level of activity behaviours. Another limitation was the advent of the COVID-19 pandemic which affected our recruitment of participants and thereby our overall sample size. The sample also consisted of people receiving care in the public health system. The profiles of participants in this study may therefore be different to those in the private healthcare system as South Africa is a highly diverse country with large cultural and socioeconomic differences. It is established that cardiovascular health is impacted by social and environmental factors [63], thus the results cannot be generalised to the majority of the population. The poor physical function in this cohort of people with OA, resulted in very little engagement in physical activity of a higher intensity and may have been because the participants were on the surgical waiting list for joint replacement. Future studies should be conducted that include participants with a greater range of severity of OA.

This study however has several strengths. Our findings are significant because of the increase in the severe burden of musculoskeletal disease occurring in Africa due to communicable diseases largely being prioritised over non-communicable diseases [37]. To our knowledge, there is no such study that has investigated the cardiometabolic effect of offsetting SB with light physical activity in people with OA. This topic warrants further investigation given the current study findings, the fact that people with OA can take part in light physical activities [24], and that simple lifestyle interventions could be useful in mitigating the burden of MSK disease [59] particularly in Africa amongst the backdrop of a strained health care system. This study highlights the need for future studies about addressing inequities in musculoskeletal care through cost-effective physical activity interventions.

In conclusion, there is a positive association between device-measured sedentary behaviour and a negative association between upright time and in particular standing time and the number of cardiometabolic disease risk factors in people with end-stage OA on the surgical wait list for total joint replacement. We suggest that targeting changes in lighter intensity activity behaviours and introducing breaks in sedentary time may have favourable effects on cardiometabolic health in people waiting joint replacements.

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References

[1] Wood AM, Brock TM, Heil K, et al. A review on the management of hip and knee osteoarthritis. Int J Chronic Dis. 2013;2013:845015. doi:10.1155/2013/845015.

[2] Palazzo C, Nguyen C, Lefevre-Colau M-M, et al. Risk factors and burden of osteoarthritis. Ann Phys Rehabil Med. 2016;59(3):134–138. doi:10.1016/j.rehab.2016.01.006.

[3] Brolan CE, Dagron S, Forman L, et al. Health rights in the post-2015 development agenda: including non-nationals. Bull World Health Organ. 2013;91(10):719–719A. doi:10.2471/BLT.13.128173.

[4] Cui A, Li H, Wang D, et al. Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies. eClinicalMedicine. 2020;29–30:100587. doi:10.1016/j.eclinm.2020.100587.

[5] Usenbo A, Kramer V, Young T, et al. Prevalence of arthritis in Africa: a systematic review and meta-analysis. PLoS One. 2015;10(8):e0133858. doi:10.1371/journal.pone.0133858.

[6] Yahaya I, Wright T, Babatunde OO, et al. Prevalence of osteoarthritis in lower middle- and low-income countries: a systematic review and meta-analysis. Rheumatol Int. 2021;41(7):1221–1231. doi:10.1007/s00296-021-04838-y.

[7] World Bank. World Bank Open Data; 2023. World Bank Open Data; [cited 2023 July 19]. Available from: https://data.worldbank.org.

[8] Brennan-Olsen SL, Cook S, Leech MT, et al. Prevalence of arthritis according to age, sex and socioeconomic status in six low and middle income countries: analysis of data from the World Health Organization study on global AGEing and adult health (SAGE) Wave 1. BMC Musculoskelet Disord. 2017;18(1):271. doi:10.1186/s12891-017-1624-z.

[9] Long H, Liu Q, Yin H, et al. Prevalence trends of site-specific osteoarthritis from 1990 to 2019: findings From the Global Burden of Disease Study 2019. Arthritis Rheumatol. 2022;74(7):1172–1183. doi:10.1002/art.42089.

[10] Brighton SW, de la Harpe AL, Van Staden DA. The prevalence of osteoarthrosis in a rural African community. Br J Rheumatol. 1985;24(4):321–325. doi:10.1093/rheumatology/24.4.321.

[11] Meyers OL, Jessop S, Klemp P. The epidemiology of rheumatic disease in a rural and an urban population over the age of 65 years. S Afr Med J. 1982;62:403–405.

[12] Solomon L, Beighton P, Lawrence JS. Osteoarthrosis in a rural South African Negro population. Ann Rheum Dis. 1976;35(3):274–278. doi:10.1136/ard.35.3.274.

[13] Kavalieratos T, Nortje M, Dunn RN. Hip and knee arthroplasty waiting list – How accurate and fair? S Afr Med J. 2017;107(4):323–326. doi:10.7196/SAMJ.2017.v107i4.12145.

[14] Coetzee M, Clifford AM, Jordaan JD, et al. Health equity profile of knee replacement patients in the South African public sector: a descriptive study. S Afr j Physiother. 2024;80(1):8. doi:10.4102/sajp.v80i1.2027.

[15] Ostir GV, Berges I-M, Smith PM, et al. Does change in functional performance affect quality of life in persons with orthopaedic impairment? Soc Indic Res. 2006;77(1):79–93. doi:10.1007/s11205-005-5554-z.

[16] Salaffi F, Carotti M, Grassi W. Health-related quality of life in patients with hip or knee osteoarthritis: comparison of generic and disease-specific instruments. Clin Rheumatol. 2005;24(1):29–37. doi:10.1007/s10067-004-0965-9.

[17] de Groot IB, Bussmann HJ, Stam HJ, et al. Small increase of actual physical activity 6 months after total hip or knee arthroplasty. Clin Orthop Relat Res. 2008;466(9):2201–2208. doi:10.1007/s11999-008-0315-3.

[18] Paxton RJ, Melanson EL, Stevens-Lapsley JE, et al. Physical activity after total knee arthroplasty: a critical review. World J Orthop. 2015;6(8):614–622. doi:10.5312/wjo.v6.i8.614.

[19] Lee J, Chang RW, Ehrlich-Jones L, et al. Sedentary behavior and physical function: objective evidence from the Osteoarthritis

Initiative. Arthritis Care Res. 2015;67(3):366–373. doi:10.1002/acr.22432.

[20] Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451–1462. doi:10.1136/bjsports-2020-102955.

[21] Wallis JA, Webster KE, Levinger P, et al. What proportion of people with hip and knee osteoarthritis meet physical activity guidelines? A systematic review and meta-analysis. Osteoarthritis Cartilage. 2013;21(11):1648–1659. doi:10.1016/j.joca.2013.08.003.

[22] Liu S-H, Eaton CB, Driban JB, et al. Comparison of self-report and objective measures of physical activity in US adults with osteoarthritis. Rheumatol Int. 2016;36(10):1355–1364. doi:10.1007/s00296-016-3537-9.

[23] Harding P, Holland AE, Delany C, et al. Do activity levels increase after total hip and knee arthroplasty? Clin Orthop Relat Res. 2014;472(5):1502–1511. doi:10.1007/s11999-013-3427-3.

[24] Frimpong E, McVeigh JA, Jagt D van Der, Mokete L, et al. Light intensity physical activity increases and sedentary behavior decreases following total knee arthroplasty in patients with osteoarthritis. Knee Surg Sports Traumatol Arthrosc. 2018;27:(7):2196–2205. doi:10.1007/s00167-018-4987-2.

[25] Caliskan E, Igdir V, Dogan O, et al. Primary total knee replacement leads to an increase in physical activity but no changes in overall time of sedentary behaviour: a retrospective cohort study using an accelerometer. International Orthopaedics (SICOT). 2020;44(12):2597–2602. [Internet]. doi:10.1007/s00264-020-04720-9.

[26] Sašek M, Kozinc Ž, Löfler S, et al. Objectively measured physical activity, sedentary behavior and functional performance before and after lower limb joint arthroplasty: a systematic review with meta-analysis. J Clin Med. 2021;10(24):5885. doi:10.3390/jcm10245885.

[27] Park E, Park H-R, Choi E-S. Barriers to and facilitators of physical activity among Korean female adults with knee osteoarthritis and comorbidity: a qualitative study. Healthcare. 2020;8(3):226. doi:10.3390/healthcare8030226.

[28] Gay C, Eschalier B, Levyckyj C, et al. Motivators for and barriers to physical activity in people with knee osteoarthritis: a qualitative study. Joint Bone Spine. 2018;85(4):481–486. doi:10.1016/j.jbspin.2017.07.007.

[29] Kozey-Keadle S, Libertine A, Lyden K, et al. Validation of wearable monitors for assessing sedentary behavior. Med Sci Sports Exerc. 2011;43(8):1561–1567. doi:10.1249/MSS.0b013e31820ce174.

[30] Plasqui G, Bonomi AG, Westerterp KR. Daily physical activity assessment with accelerometers: new insights and validation studies. Obes Rev. 2013;14(6):451–462. doi:10.1111/obr.12021.

[31] Strath SJ, Kaminsky LA, Ainsworth BE, et al. Guide to the assessment of physical activity: clinical and research applications: a scientific statement from the American Heart Association. Circulation. 2013;128(20):2259–2279. doi:10.1161/01.cir.0000435708.67487.da.

[32] Chaput J-P, Saunders T J, Carson V. Interactions between sleep, movement and other non-movement behaviours in the pathogenesis of childhood obesity. Obes Rev. 2017;18(S1):7–14. doi:10.1111/obr.12508.

[33] Brisson NM, Gatti AA, Maly MR. Association of pain and steps per day in persons with mild-to-moderate, symptomatic knee osteoarthritis: a mixed-effects models analysis of multiple measurements over three years. Arthritis Care Res. 2020;72(1):114–121. doi:10.1002/acr.23842.

[34] Frimpong E, Van Der Jagt D, Pietrzak J, et al. Improvements in objectively measured activity behaviors do not correlate with improvements in patient-reported outcome measures following total knee arthroplasty; [cited 2021 August 31]. Available from: https://pubmed.ncbi.nlm.nih.gov/31722854/.

[35] White DK, Tudor-Locke C, Felson DT, et al. Do radiographic disease and pain account for why people with or at high risk of knee osteoarthritis do not meet physical activity guidelines? Arthritis Rheum. 2013;65(1):139–147. doi:10.1002/art.37748.

[36] Govender K, Girdwood S, Letswalo D, et al. Primary healthcare seeking behaviour of low-income patients across the public and private health sectors in South Africa. BMC Public Health. 2021;21(1):1649. doi:10.1186/s12889-021-11678-9.

[37] Adebajo A, Gabriel SE. Addressing musculoskeletal health inequity in Africa. Arthritis Care Res. 2010;62(4):439–441. doi:10.1002/acr.20032.

[38] Lavie CJ, Ozemek C, Carbone S, et al. Sedentary behavior, exercise, and cardiovascular health. Circ Res. 2019;124(5):799–815. doi:10.1161/CIRCRESAHA.118.312669.

[39] Young DR, Hivert M-F, Alhassan S, et al. Sedentary behavior and cardiovascular morbidity and mortality: a science advisory from the american heart association. Circulation. 2016;34(13):e262–e279. doi:10.1161/CIR.0000000000000440.

[40] Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. Lancet. 2016;388(10051):1302–1310. doi:10.1016/S0140-6736(16)30370-1.

[41] Wang H, Bai J, He B, et al. Osteoarthritis and the risk of cardiovascular disease: a meta-analysis of observational studies. Sci Rep. 2016;6(1):39672. doi:10.1038/srep39672.

[42] Hall AJ, Stubbs B, Mamas MA, et al. Association between osteoarthritis and cardiovascular disease: systematic review and meta-analysis. Eur J Prev Cardiol. 2016;23(9):938–946. doi:10.1177/2047487315610663.

[43] Hawker GA, Croxford R, Bierman AS, et al. All-cause mortality and serious cardiovascular events in people with hip and knee osteoarthritis: a population based cohort study. PLoS One. 2014;9(3):e91286. doi:10.1371/journal.pone.0091286.

[44] Mathieu S, Couderc M, Tournadre A, et al. Cardiovascular profile in osteoarthritis: a meta-analysis of cardiovascular events and risk factors. Joint Bone Spine. 2019;86(6):679–684. doi:10.1016/j.jbspin.2019.06.013.

[45] McKevitt S, Healey E, Jinks C, et al. The association between comorbidity and physical activity levels in people with osteoarthritis: secondary analysis from two randomised controlled trials. Osteoarthr Cartil Open. 2020;2(2):100057. doi:10.1016/j.ocarto.2020.100057.

[46] Liu S-H, Waring ME, Eaton CB, et al. Association of objectively measured physical activity and metabolic syndrome among US adults with osteoarthritis. Arthritis Care Res. 2015;67(10):1371–1378. doi:10.1002/acr.22587.

[47] Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. Med Sci Sports Exerc. 2005;37(11 Suppl):S531–S543. doi:10.1249/01.mss.0000185657.86065.98.

[48] Klässbo M, Larsson E, Mannevik E. Hip disability and osteoarthritis outcome score. An extension of the Western Ontario and McMaster Universities Osteoarthritis Index. Scand J Rheumatol. 2003;32(1):46–51. doi:10.1080/03009740310000409.

[49] Roos EM, Klässbo M, Lohmander LS. WOMAC osteoarthritis index. Reliability, validity, and responsiveness in patients with arthroscopically assessed osteoarthritis. Western Ontario and MacMaster Universities. Scand J Rheumatol. 1999;28(4):210–215. doi:10.1080/03009749950155562.

[50] Coqueiro RdS, Santos MC, Neto JdSL, et al. Validity of a portable glucose, total cholesterol, and triglycerides

multi-analyzer in adults. Biol Res Nurs. 2014;16(3):288–294. doi:10.1177/1099800413495953.

[51] Vandenbroucke JP, von Elm E, Altman DG, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. PLoS Med. 2007;4(10):e297. doi:10.1371/journal.pmed.0040297.

[52] Tudor-Locke C, Schuna JM, Barreira TV, et al. Normative steps/day values for older adults: NHANES 2005–2006. J Gerontol A Biol Sci Med Sci. 2013;68(11):1426–1432. doi:10.1093/gerona/glt116.

[53] de Hoop AMS, Kloek CJJ, Pisters MF, et al. Movement behaviour patterns in patients with hip and/or knee osteoarthritis in the physical therapy setting: a cross-sectional study. BMC Musculoskelet Disord. 2020;21(1):651. doi:10.1186/s12891-020-03644-0.

[54] Sliepen M, Mauricio E, Lipperts M, et al. Objective assessment of physical activity and sedentary behaviour in knee osteoarthritis patients – beyond daily steps and total sedentary time. BMC Musculoskelet Disord. 2018;19(1):64. doi:10.1186/s12891-018-1980-3.

[55] O'Brien MW, Kivell MJ, Wojcik WR, et al. Influence of anthropometrics on step-rate thresholds for moderate and vigorous physical activity in older adults: scientific modeling study. JMIR Aging. 2018;1(2):e12363. doi:10.2196/12363.

[56] Dunlop DD, Song J, Lee J, et al. Physical activity minimum threshold predicting improved function in adults with lower limb symptoms. Arthritis Care Res. 2017;69(4):475–483. doi:10.1002/acr.23181.

[57] Johns JA, Frayne RJ, Goreham JA, et al. The Bout cadence method improves the quantification of stepping cadence in free-living conditions. Gait Posture. 2020;79:96–101. doi:10.1016/j.gaitpost.2020.04.014.

[58] Matharu GS, Culliford DJ, Blom AW, et al. Projections for primary hip and knee replacement surgery up to the year 2060: an analysis based on data from The National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. Ann R Coll Surg Engl. 2022;104(6):443–448. doi:10.1308/rcsann.2021.0206.

[59] Svege I, Nordsletten L, Fernandes L, et al. Exercise therapy may postpone total hip replacement surgery in patients with hip osteoarthritis: a long-term follow-up of a randomised trial. Ann Rheum Dis. 2015;74(1):164–169. doi:10.1136/annrheumdis-2013-203628.

[60] Saunders TJ, McIsaac T, Douillette K, et al. Sedentary behaviour and health in adults: an overview of systematic reviews. Appl Physiol Nutr Metab. 2020;45(10 (Suppl. 2):S197–S217. doi:10.1139/apnm-2020-0272.

[61] Bell AC, Richards J, Zakrzewski-Fruer JK, et al. Sedentary behaviour-a target for the prevention and management of cardiovascular disease. Int J Environ Res Public Health. 2022;20(1):532. doi:10.3390/ijerph20010532.

[62] LaCroix AZ, Bellettiere J, Rillamas-Sun E, et al. Association of light physical activity measured by accelerometry and incidence of coronary heart disease and cardiovascular disease in older women. JAMA Netw Open. 2019;2(3):e190419. doi:10.1001/jamanetworkopen.2019.0419.

[63] Powell-Wiley TM, Baumer Y, Baah FO, et al. Social determinants of cardiovascular disease. Circ Res. 2022;130(5):782–799. doi:10.1161/CIRCRESAHA.121.319811.