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Assessing moderate-to-vigorous physical activity in hip and knee osteoarthritis using accelerometers: Implications of different patterns and cut-points for health and well-being

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ABSTRACT

Objective: This cross-sectional study explored how using age-specific and non-age-specific cut-points to assess moderate-to-vigorous physical activity (MVPA) measured by GT3X accelerometers affected bouted and total volume MVPA associations with health and well-being.
Methods: MVPA correlations with physical function, BMI, joint pain, quality of life, anxiety and depression were tested. Steiger's z compared the strength of these correlations for each pair of cut-points.
Results: A total of 109 adults with hip/knee osteoarthritis [M= 63.8 years (±10.58), 63.3% women] participated. Applying age-specific cut-points resulted in significantly more time classified as MVPA (76/9.5min total volume/bouted) compared to non-age-specific (38.8/7min total volume/bouted). Only total volume MVPA correlations differed significantly as a function of cut-points for self-reported function, quality of life, anxiety and depression ($p \leq .05$). For age-specific cut-points, more time spent in MVPA was associated with a worse psychological profile.
Discussion: Applying age-specific cut-points for MVPA assessment in older adults with lower limb OA had implications for MVPA associations with health and well-being when total volume, but not bouted, MVPA was considered. Age-specific total volume MVPA needs further understanding regarding patterns and affective responses it comprises. Bouted MVPA is an important pattern for MVPA accrual, but probably not an applicable PA target for many patients.

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KEYWORDS
Bouted MVPA; non-bouted MVPA; age-specific; cut-points; hip and knee osteoarthritis; MVPA accumulation and physical function; MVPA accumulation and well-being

Introduction

Hip and knee osteoarthritis (OA) impact negatively on the individuals' physical and mental health and functional ability, and is a leading cause of disability worldwide. In comparison to the general population, people with OA are at higher risk of cardiovascular morbidity and mortality (Hall et al., 2016; Veronese et al., 2016), and a large proportion experience anxiety and depressive symptoms (Stubbs et al., 2016). Negative psychological states such as depression are related to worse pain (Bartley et al., 2017) and physical function (Scopaz et al., 2009).

Being physically active is considered essential for the effective management of hip and knee OA (Rausch Osthoff et al., 2018). Moderate-to-vigorous PA (MVPA) is recognised to be linked with health benefits in the general population, hence, international PA recommendations include 150 minutes of MVPA/week, either as bouted (i.e., accumulated in bouts of ≥10-minutes) (U.S., 2008) or more recently as total volume PA (i.e., accumulated on a minute-by-minute basis throughout the day) (U.S., 2018). In the absence of OA-specific recommendations for PA volume or pattern, the degree to which guidelines for the general population are met is an outcome of interest when managing patients with OA. Using both bouted (Dunlop, Song, Semanik, Chang et al., 2011, p. 10; Sun et al., 2014) and total volume (Chang et al., 2020; Dunlop et al., 2019; Wallis et al., 2013) MVPA definitions, the majority of people with lower limb OA do not meet the guidelines, with the proportion meeting guidelines being particularly low for bouted MVPA.

With regard to OA-specific outcomes, evidence from longitudinal cohort studies using accelerometry demonstrates that time spent in MVPA has a protective effect against functional decline and disability in people with or at risk of lower limb OA (Dunlop, Song, Semanik, Sharma et al., 2011; White et al., 2017; Dunlop et al., 2019). It is presently not clear whether bouted or total MVPA time is a better predictor: for example, more bouted MVPA was found to have a graded relationship with less disability in 2 years, even without reaching 150 minutes/week (Song et al., 2017). On the contrary, Dunlop et al. (2019) found that total volume MVPA was a better predictor of disability-free status in 4 years when compared to bouted MVPA, light PA and sedentary time.

Classification of accelerometer-measured MVPA adds to the complexity of MVPA assessment. Cut-points are applied to acceleration counts per minute (cpm) to classify time spent in light, moderate or vigorous PA or sedentary time. Validation studies in various populations identify cut-points that correspond to a

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specific range in intensity or energy expenditure (3–6 METs for MVPA). Variability in PA classification based on different cut-points is notable (Watson et al., 2014). In lower limb OA research, uniaxial GT1M Actigraph® accelerometers and Troiano and colleagues' (Troiano et al., 2008) cut-points have been commonly used (Chang et al., 2020; Dunlop et al., 2019, 2017; Dunlop, Song, Semanik, Chang et al., 2011; Sun et al., 2014; White et al., 2017). However, Troiano's MVPA cut-points, >2019 cpm on the vertical axis, derive from the weighted average from four validation studies investigating young healthy adults (Troiano et al., 2008). Thus, these cut-points may be inappropriate for use in OA populations who tend to be older and have lower walking speed and slower metabolism (Schrack et al., 2012). Therefore cut-points validated in older adults have been recommended for research with this age group (Ekelund et al., 2019; Watson et al., 2014). When non-age-specific cut-points are used with older adults, it has been suggested that light-intensity PA (LPA) might actually incorporate MVPA and explain the LPA benefits found for health and disability (Dunlop et al., 2014; Ekelund et al., 2019).

The advancement of Actigraph® accelerometers from uniaxial (GT1M) to triaxial (GT3X models) has enabled more accurate assessment of PA intensity and energy expenditure (Santos-Lozano et al., 2013; Zisko et al., 2015). In a validation study with older healthy adults (65–80 years), a protocol of various activity conditions and GT3X accelerometers were used (Santos-Lozano et al., 2013). They identified 2751 cpm from three axis counts (vector magnitude) as the cut-point between LPA and MVPA. Although uniaxial cpm from GT1M accelerometers and vertical counts from GT3X accelerometers are comparable (Kaminsky & Ozemek, 2012), implications of using age-specific, triaxial cut-points in comparison to the non-age-specific ones commonly used, have not been examined. Also, outcomes related to physical health are often examined in PA research, e.g., physical function in OA (Dunlop et al., 2019), mortality and cardiovascular disease risk in general populations (Ekelund et al., 2019), whereas psychological and quality of life outcomes are studied less often. Given that disease-related physical factors do not sufficiently explain variability in PA levels in people living with lower limb OA (Kanavaki et al., 2017; Wallis et al., 2013), the role of well-being and psychological factors as predictors and outcomes of PA, needs further investigation.

The objective of this study was to explore how using two different cut-points (age-specific (Santos-Lozano et al., 2013), non-age-specific (Troiano et al., 2008)) to assess MVPA affects associations of MVPA with health and well-being. Specifically, we compared: (1) time spent in total volume and bouted MVPA and the proportion of people meeting the 150 minutes/week guidelines when applying the two different cut-points; (2) the associations between total volume and bouted MVPA with health and well-being indicators when applying the two different cut-points.

Materials and methods

Research design and setting

This was a multicentre, observational, cross-sectional study. Participant recruitment took place in secondary care and community settings in England between February 2017 and February 2018 (Figure 1). Eligible individuals interested to participate visited the respective site, gave written informed consent and completed physiological and self-reported measures. Participants took a waist-worn GT3X accelerometer to wear for one week during waking hours, except during water-based activities. Study reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement (Von Elm et al., 2014). The study received ethical approval from the West Midlands Research Ethics Committee and Health Research Authority (16/WM/0371).

Sample size calculations were based on a minimum of 85 cases required to detect a medium effect size (r = 0.30) with Pearson's correlation, with a .80 power and significance criterion a = .05 in a product-moment correlation (Cohen, 1992).

Participants

Eligible participants were adults ≥40 years with a diagnosis of hip or knee OA, confirmed by a healthcare professional (self-reported physician-made diagnosis for community recruits).

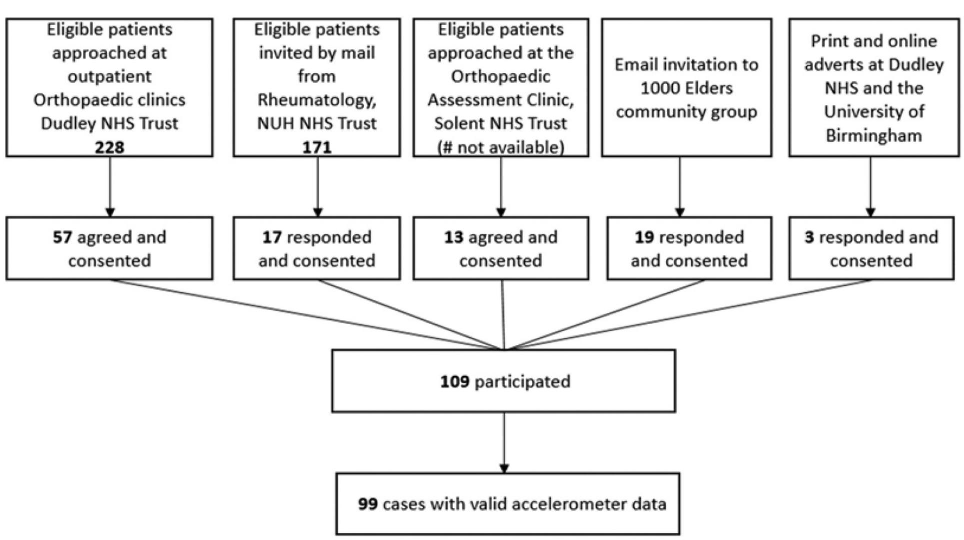

Figure 1. Participant recruitment flow diagram.

Participants were excluded if using aids other than a walking stick to ambulate or having a diagnosis of other forms of arthritis (e.g., inflammatory arthritis) or of a cognitive disorder that causes significant memory loss (self-reported).

Variables and data sources

Accelerometer-measured PA GT3X Actigraph accelerometers (ActiGraph, LLC., Pensacola, Florida, USA) were used to assess PA over a seven-day period. The Actigraph GT3X+, and its newest generations of wGT3X and wGT3X-BT, are lightweight (27 g) and compact (3.8x3.7x1.8 cm) activity monitors that record accelerations in g's for 3 axes (horizontal, vertical, perpendicular). Devices were initialized to record raw data in the default frequency of 30 Hz and in 1-sec sample rate, which were then summed in 60-sec epochs (counts per minute). Raw data from the vertical axis and the 3 axes vector magnitude were examined. Non-wear time (Choi et al., 2011) was excluded from the analysis and minimum wear-time of 10-hours/day for at least four days including a weekend day was used as criterion for valid cases (Keadle et al., 2014). Data was processed first using cpm on the vertical axis, then using the vector magnitude. Cut-points applied for MPA and VPA classification were: (a) non-age-specific 2020–5998cpm and ≥5999cpm respectively on vertical axis (Troiano et al., 2008); (b) age-specific 2751–9358cpm and ≥9359 on vector magnitude (Santos-Lozano et al., 2013). MVPA is the sum of MPA and VPA. VPA represented a very small proportion of daily MVPA and was not examined separately in subsequent analyses. Bouted MVPA represents MVPA bouts of ≥10 min allowing for up to 2 min with cpm below the threshold. The 2 min allowance, the selected sample rate and post-processed epoch duration are in accordance with those used in the relevant algorithm validation studies (Santos-Lozano et al., 2013; Troiano et al., 2008) and OA epidemiological studies (Dunlop, Song, Semanik, Chang et al., 2011). Minutes/day, minutes/week and percentage of total wear time spent in MVPA were calculated. A binomial variable, i.e., meeting MVPA guidelines or not, was computed for each set of cut-points. LPA and sedentary time (ST) using uniaxial and triaxial cpm were also calculated, as their assessment is relevant to cut-point choices. For ST classification the cut-points applied were: <100cpm on vertical axis (Troiano et al., 2008) and <200cpm on vector magnitude, as previously validated in adults ≥65 years (Aguilar-Farias et al., 2014). Cpm that fell between ST and MVPA were classified as LPA.

Physical function was assessed by the 20-metre Timed Walk Test. Participants were asked to walk at their normal pace along a 20-metre marked area and a researcher used a stopwatch to count the time required from start to finish. Short distance, self-paced timed tests have showed good reliability and validity in knee OA (Marks, 1994).

BMI Height was measured by a stadiometer and results were imputed in a bio-electrical impedance analysis scale (Tanita MC-780 MA P), which calculated BMI.

Demographic and disease-related characteristics Demographic characteristics and financial strain were assessed with multiple choice questions, except for age. Free-text questions inquired about disease-related variables, such as medication and other treatment.

Self-reported joint pain and physical function in daily living The 9-item Pain and the 17-item Activities of Daily Living (ADL) subscales from the Knee Injury and Osteoarthritis Outcome Score (KOOS) (Roos & Lohmander, 2003) and Hip Disability and Osteoarthritis Outcome Score (HOOS) (Klassbo et al., 2003) were used to assess pain and physical function. Responses range from "none" to "extreme" on a 5-point scale. Normalised scores were used, 0 indicating extreme symptoms and 100 indicating no symptoms. KOOS and HOOS are validated scales with high test–retest reliability (Collins et al., 2011; Klassbo et al., 2003). A joint score, i.e., hip or knee, was created for pain and ADL respectively to enable inclusion of all participants in the analysis.

Physical and psychological quality of life The 7-item Physical and 6-item Psychological subscales from the World Health Organisation Quality of Life-BREF (WHO-QOL-BREF) (The Whoqol Group u, 1998) were used, to assess physical and mental health QoL respectively. Transformed scores from 5-point scale responses range from 4 to 20, higher values indicating better QoL. WHO-QOL-BREF has shown good test–retest reliability, discriminant and content validity (Skevington et al., 2004).

Anxiety and depressive symptoms were assessed by the Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983). Responses to the two 7-item subscales range from 0 to 3. Summed scale scores range from 0 to 21, higher values indicating more severe symptoms. HADS is a valid instrument for assessing depression and anxiety (Bjelland et al., 2002).

Data analysis

Statistical analysis was performed using SPSS 24 statistics software and an online calculator for Steiger's z-statistic (Lee & Preacher, 2013). All variables were examined for normality of distributions graphically and by skewness and kurtosis values (Field, 2018). Wilcoxon signed ranks test compared daily MVPA (total volume, bouted) assessed by non-age-specific and age-specific cut-points. To test differences in the proportion of participants meeting the MVPA guidelines, Fisher's exact test was used.

Correlation of MVPA with health and well-being indicators when applying different accumulation patterns

The relationships of total volume and bouted MVPA (as % of total wear-time) with BMI, objective and self-reported physical function, joint pain, QoL, anxiety and depressive symptoms were tested with Pearson's product moment correlation coefficient. 95% confidence intervals, bias corrected and accelerated, were calculated. For bouted MVPA, three extreme outliers were removed from the analysis. Steiger's z test compared the bivariate correlations (r coefficients) for age-specific/non-specific bouted and age-specific/non-specific total volume MVPA pairs.

Missing data

Scale instructions were followed for handling missing data where available (KOOS/HOOS, WHOQOL-BREF). Up to one missing item per subscale was allowed for the remainder of the scales administered.

Results

Participant characteristics

One hundred and nine individuals with hip or knee OA took part in the study, 69.70% recruited from secondary healthcare (Figure 1). Mean (SD) age was 63.8 years (±10.6), mean (SD) BMI was 29.7 (± 4.9) kg/m^2; 63.3% were women, 60.6% married, 52.3% retired; 29.5% reported education to University level, 24.6% no higher education. No financial strain was reported by 60.03%. Regarding OA, 68.8% reported taking medication or food supplement (9.2%), 52.3% had had injections and 44.8% some OA-related surgical procedure; 55% reported one or more comorbidities. Mean scores of the measures are presented in (Table 1).

Ten participants with missing data for MVPA were excluded from analysis, nine for physical function, four for BMI, one for ADL and physical QoL, two for psychological QoL and HADS.

Physical activity assessment

Participants wore the accelerometers for 6.46 (SD = .92) days. Based on non-age-specific cut-points, participants spent on average approximately 12hs per day in ST, 85 min in LPA and 39 min in MVPA. Based on age-specific cut-points, participants spent on average 11hs per day in ST, 120 min in LPA and 76 min in MVPA. Time spent in bouted MVPA was approximately 7 and 10 min respectively, that is less than one bout/day on average (Table 2).

Table 1. Descriptive statistics for the study variables.

	Mean ± SD	Range (scale range)	Cronbach's a
BMI (kg/ m^2)	29.68 ± 4.91	20.70–43.40	-
Women	29.08 ± 4.71		
Men	30.73 ± 5.15		
Physical function (20 m timed walk test; sec)	18.43 ± 3.92	11.23–29.05	-
Joint ADL (KOOS/HOOS ADL)	59.88 ± 21.34	15.00–100 (0–100)	0.95/0.98
Joint pain (KOOS/HOOS pain)	63.46 ± 21.53	13.24–100 (0–100)	0.90/0.96
Quality of life-physical (WHOQOL-BREF)	13.60 ± 3.07	7.43–18.86 (4–20)	0.85
Quality of life-psychological (WHOQOL-BREF)	14.91 ± 2.44	8.67–20.00 (4–20)	0.82
Anxiety (HADS)	6.84 ± 4.07	0–17 (0–21)	0.82
Depressive symptom (HADS)	4.87 ± 3.39	0–14 (0–21)	0.77

BMI = body mass index; ADL = difficulties with activities of daily living; KOOS = knee injury and osteoarthritis outcome score; HOOS = hip disability and osteoarthritis outcome score; WHOQOL-BREF = World Health Organisation Quality Of Life-BREF; higher scores for physical function, anxiety and depressive symptoms indicate worse outcomes; higher scores for joint ADL, pain, physical QoL and psychological QoL indicate favourable outcomes.

Table 2. Descriptive statistics for physical activity levels using two sets of cut-points.

	Daily Minutes Mean ± SD	
	Age-specific	Non-age-specific
Light PA	121.07 ± 38.37	85.19 ± 29.39
Moderate PA	73.82 ± 31.86	36.48 ± 20.34
Vigorous PA	2.20 ± 1.20	2.30 ± 1.93
Moderate-to-Vigorous PA, total	76.03 ± 32.55	38.78 ± 21.37
Moderate-to-Vigorous PA, bouted	9.46 ± 14.39	6.97 ± 12.24
Sedentary time	654.61 ± 73.55	727.48 ± 70.40

n = 99.

Time spent in MVPA and meeting the guidelines

Wilcoxon signed-rank test showed that total volume MVPA was significantly higher when assessed by age-specific in comparison to non-age-specific cut-points, $z = -8.60$, $p < .001$. Similarly, bouted MVPA was significantly higher when assessed by age-specific in comparison to non-age-specific cut-points, $z = -6.11$, $p < .001$. The MVPA pattern by cut-point combination is presented in a contingency table (Table 3). The proportion of participants who met the guidelines was significantly different between the two cut-points both for total volume (Fisher's Exact Test $p = .032$) and bouted MVPA (Fisher's exact test $p < .001$).

MVPA pattern correlations with health and well-being and comparison of correlation coefficients between cut-points (*Table 4*)

Total Volume MVPA Pearson's r and 95% CIs showed a significant, moderate correlation between total MVPA and some physical health outcomes (physical function, BMI), for both cut-points; also, with physical QoL for non-age-specific counts only. Higher MVPA levels were related to better physical function, lower BMI and better physical QoL. Regarding psychological variables, for age-specific counts only and based on the 95% CIs, psychological QoL and depressive symptoms presented a small-to-moderate correlation with MVPA. For higher levels of MVPA, psychological QoL tended to be lower and depressive symptoms higher.

Steiger's z test revealed significant differences between the cut-points in some physical health variables (joint ADL, physical QoL), and all psychological variables. Non-age-specific MVPA was associated to better physical and mental health vs no associations for age-specific MVPA. In addition, non-age-specific MVPA had no association with anxiety, depression and psychological QoL vs significant associations (or trend) with worse outcomes for age-specific MVPA.

Table 3. Proportion (%) of participants meeting the 150 min/week MVPA guidelines.

	Bouted MVPA		Total MVPA	
Guidelines met?	Age-specific	Non-age-specific	Age-specific	Non-age-specific
Yes	13.3%	10.2%	98%	81.6%
No	86.7%	89.8%	2%	18.4%
Fisher's exact test	p < .001		p = .032	

n = 98.

Table 4. Bouted and total MVPA correlations with health and well-being outcomes and comparisons of correlation coefficients between cut-points.

	MVPA (% of wear time) r [95% CI BCa]					
	Age-specific Bouted	Non-age-specific Bouted	Steiger's z-value	Age-specific Total	Non-age-specific Total	Steiger's z-value
Physical function	−.31** [−0.44,-0.17]	−.34*** [−0.47,-0.22]	.74	−.33** [−0.48,-0.15]	−.21* [−0.38,-0.03]	1.46
BMI	−.12 [−0.26, 0.04]	−.11 [−0.26, 0.02]	−.24	−.22* [−0.38,-0.04]	−.23* [−0.39,-0.04]	−0.16
Joint ADL	.31** [0.47, 0.14]	.32*** [0.47, 0.15]	−.25	.02 [0.22,-0.17]	.18 [0.36,-0.00]	2.48*
Joint pain	.29** [0.47, 0.10]	.29** [0.43, 0.10]	0	.04 [0.24,-0.15]	.14 [0.33,-0.05]	1.55
QoL physical	.28** [0.07, 0.47]	.29** [0.12, 0.44]	−.25	.00 [−0.22, 0.25]	.21* [0.02, 0.40]	−3.20**
QoL psychological	.07 [−0.09, 0.21]	.02 [−0.16, 0.18]	1.19	−.17 [−0.34,-0.02]	−.03 [−0.22, 0.15]	2.17*
Anxiety	−.18 [−0.35,-0.00]	−.14 [−0.29, 0.04]	−.09	.20 [−0.00, 0.37]	.06 [−0.14, 0.23]	2.13*
Depressive symptoms	−.27** [−0.40,-0.12]	−.26* [−0.38,-0.11]	−.25	.18 [0.02, 0.35]	.00 [−0.19, 0.21]	2.78**

CI BCa = Confidence Intervals Bias corrected and accelerated; ADL = activities of daily living; QoL = Quality of Life; *p < .05, **p < .01, ***p < .001.
Physical function n = 91, BMI n = 95, joint ADL/QoL physical/QoL psychological n = 97, joint pain n = 98, anxiety/depressive symptoms n = 96.

Bouted MVPA For both cut-points, Pearson's r and 95% CIs revealed significant moderate correlations of bouted MVPA with most of physical health variables. More time spent in bouted MVPA was related to better physical function, less joint pain, less difficulties in activities of daily living and better perceived physical QoL. Also for both cut-points, more bouted MVPA was related to lower levels of depressive symptoms. For age-specific MVPA (based on 95% CIs), anxiety presented a small-to-moderate negative correlation with bouted MVPA. Steiger's z test showed no significant differences in correlation coefficients between Santos-Lozano's and Troiano's MVPA in regard to any of the observed bivariate correlations.

Discussion

This was the first study to explore how using age-specific and non-age-specific cut-points for calculating MVPA, affected associations of total and bouted MVPA with health and well-being indicators in individuals with hip and knee OA. Applying age-specific cut-points resulted in more time being classified as bouted and total MVPA and a higher proportion of participants meeting MVPA guidelines than when non-age-specific cut-points were used. Significant variation in time spent in MVPA when different cut-points are applied, is commonly reported (Watson et al., 2014). However, the finding that this variation did not affect the associations of bouted MVPA with health and well-being indicators, but affected most of total volume MVPA associations, is novel. Notably, regardless of cut-points the vast majority of participants met the guidelines of 150 min/ week of total MVPA, i.e., 98% and 81.6%, in contrast to a minority of 13.3% and 10.2% based on time spent on bouted MVPA.

Only bouted MVPA was consistently associated with a positive health and well-being profile regardless of cut-points used, indicating that bouted MVPA is a distinct and important PA pattern. More time spent in bouted MVPA was related to less pain and difficulties in ADL, better physical QoL, lower levels of depressive symptoms and anxiety (trend). In explicating these findings, it might be the case that individuals with less disabling OA are more likely to engage in bouted MVPA and consequently experience less depression and anxiety. It might also be the case that those engaging in more bouted MVPA manage their OA symptoms better, have better physical function (Dunlop, Song, Semanik, Sharma et al., 2011; Song et al., 2017) and therefore better QoL and well-being (Tanaka et al., 2015); or that those who report higher levels of depression and anxiety, experience greater disability and worse QoL (Bartley et al., 2017; Scopaz et al., 2009). For example, depressive symptoms predicted a decline in daily steps over two years in adults with or at risk of knee OA (White et al., 2016), while among individuals with painful knee OA, those with high positive affect spent more time walking (White et al., 2012). The above interpretations are not mutually exclusive since there is a known interaction between physical and psychological variables (Bartley et al., 2017). It is important to note though, that average bouted MVPA time was low, i.e., 66 and 49 minutes per week respectively for age-specific and non-age-specific cut-points, and also skewed, with 33.7% and 42.9% of participants respectively recording zero bouts and about 70% recording less than one bout/day for both cut-points. These numbers indicate that bouted MVPA benefits may not be applicable to a large proportion of individuals with OA. Notably, though, the link to better outcomes was sustained for intensity lower than previously examined.

For total volume MVPA, age-specific cut-points captured broader aspects of lifestyle PA than what is commonly assessed in OA research with non-age specific cut-points. Interestingly, it tended to negatively correlate with well-being outcomes. Thirty-eight minutes classified as total volume MVPA with age-specific cut-points, corresponds to non-age-specific LPA. More time spend at this intensity might represent a slow-down in daily activities due to OA symptoms (Daugaard et al., 2018; Song et al., 2018), which is reflected in well-being indicators. LPA has been suggested as an achievable and sufficient target behaviour in lower limb OA and older populations (Dunlop et al., 2014; Ekelund et al., 2019). However, an association with worse QoL and psychological symptoms would make such a target questionable given that from a PA promotion perspective, positive PA experiences, attitude and affect seem to characterise those who adhere to more PA (Kanavaki et al., 2017; White et al., 2012). Further research is needed to unravel these findings and enable targeted recommendations. For example, different behavioural patterns classified together under this variable or subgroup differences, e.g., in affective responses (Ekkekakis & Brand, 2018), which were not examined in this study, can potentially explain the negative, although small, MVPA-wellbeing associations.

Regarding physical variables, present findings are in line with existing literature. Physical function (timed walk test) showed moderate correlations across cut-points and MVPA patterns, as has been previously reported (Dunlop et al., 2019; Kraus et al., 2019). Only total MVPA, regardless of cut-points, was associated with lower BMI. The limited time spent in bouted MVPA was probably insufficient for weight management, hence the non-significant correlations. As with general population (Jefferis et al., 2019), research in OA supports the benefits of moving more and sitting less (Song et al., 2017). A threshold of 60 min total MVPA per week, non-age-specific, has been proposed as a minimum for maintenance of function in daily living and as an intermediate goal towards a more active lifestyle (Dunlop et al., 2019). Under the light of present findings, it would be interesting to explore age-specific minimum thresholds.

Strengths and limitations

The present study, reported in line with STROBE, is novel and results are critical of existing approaches to PA assessment in lower limb OA, with important implications for future research and clinical recommendations. Firstly, in light of the outcomes studied, selection of cut-points appears less significant when bouted MVPA is examined, whereas there are implications for certain outcomes when research focus is on concomitants of total volume MVPA. Nevertheless, age-specific cut-points provide a more accurate assessment of time spent in moderate PA intensity in older adults (Santos-Lozano et al., 2013). Secondly, focusing solely on meeting MVPA guidelines does not appear to be a meaningful target in older adults with OA i.e., it should not be considered automatically as an indicator of health and well-being. Setting 150 minutes of weekly MVPA as a target is unrealistic regarding bouted, and not necessarily relevant to certain OA and well-being outcomes regarding total volume MVPA. Increasing age-specific bouted MVPA could be an appropriate target for PA promotion and prescription in lower limb OA. Still caution is needed in generalising this target, as this may not be applicable for a large proportion of this patient group. Thirdly, total volume, age-specific MVPA needs further exploration as to what patterns and activities it entails rather than being set as a general target in PA promotion. Combination of methods, like objective PA assessment and qualitative exploration, could help in this direction. Lastly, well-being and quality of life factors should be taken into account in PA research along with physical health, as they can fill in missing information in understanding health behaviours.

Certain study limitations should also be acknowledged. The study sample has characteristics that might limit generalisation of the findings, i.e., the present sample is marked by higher levels of MVPA and lower levels of anxiety and depressive symptoms than previously reported in hip and knee OA (Bjelland et al., 2002; Dunlop, Song, Semanik, Chang et al., 2011). Only 10–20% of invited eligible participants from secondary care took part in the study. Bias in sampling is an acknowledged problem in PA research, as volunteers are unlikely to be representative of the whole population which is likely to also incorporate individuals inactive and disinterested towards PA (Ekkekakis & Brand, 2018). However, in the present sample, there was a good representation regarding disease severity, age and gender, which are known PA determinants. Also, to minimise selection bias between those agreeing to participate and those who didn't, the individual's usual healthcare team was involved in the face-to-face recruitment process to increase individuals' motivation for participation whilst avoiding any pressure. Bouted MVPA was not normally distributed since a significant proportion of participants had zero bouts, i.e., 42% for non-age-specific and 33% for age-spefic cut-points. Participants with zero bouts did not significantly differ from the rest with regard to age and gender and significance of associations was based on confidence intervals rather than p value. Regarding methodological aspects of bouted MVPA calculation, allowing for up to 2 minutes below the intensity threshold may have led to an increase in estimated bout frequency and duration (Ayabe et al., 2014) and overestimation of heart rate (Ayabe & Kumahara, 2020) compared to uninterrupted bouts. In any case, time spent in bouted MVPA was limited and interrupted bouts may better represent movement patterns of middle and older-aged adults living with OA. The MVPA associations tested accounted for wear-time only (i.e., MVPA as % of total wear time) and subgroup analysis was not performed due to sample size. Still, the selected analysis offered an easily comparable overview of associations across cut-points and MVPA patterns. Lastly, false positive outcomes are likely due to multiple tests for the given sample size. Time and resource limitations did not allow for recruitment of a bigger sample. Future research with larger samples or focusing on subgroups (e.g., hip or knee, patients with worse psychological profile) is needed to confirm present findings.

Conclusion

The application of age-specific cut-points for MVPA assessment in older adults with lower limb OA had implications for MVPA associations with health and well-being indicators when total volume, but not bouted, MVPA was considered. The findings indicate that bouted MVPA is a distinct PA pattern with stronger links to health and wellbeing, and age-specific bouted MVPA is a more attainable target than non-age-specific. Yet caution is needed when generalising research findings to subgroups who do not do any bouted MVPA. Total volume MVPA appears to capture various behaviours with potentially complex links to wellbeing. Further exploration of patterns and subgroup differences is needed as it could be a key factor in the promotion of a more active lifestyle in this population.

Disclosure statement

The authors report no conflict of interest.

Highlights

- Bouted MVPA was consistently associated with a positive health and well-being profile regardless of cut-points used, indicating that it is a distinct and important pattern for accruing MVPA, although difficult to attain for people with hip or knee OA. Nevertheless, increasing age-specific bouted MVPA should be a target for interventions promoting PA in this population.
- For total volume MVPA, choice of cut-points affected its associations with health and well-being indicators. Age-specific MVPA was associated with a more compromised well-being profile. Further research is needed to unravel behavioural patterns and subgroup differences before setting health behaviour targets.
- Along with physical outcomes, indicators of psychological well-being should be taken into account in PA research, as enhanced mental health outcomes could be a key factor in the adoption and promotion of a more active lifestyle in older adults living with OA.

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