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24-hour Movement Behaviours and Bone Mineral Density in Older Adults - A Rapid Narrative Review

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Abstract

Introduction: Understanding daily movement patterns (i.e., the relative proportion of time spent on Sedentary behaviour (SB), light physical activity (LPA), moderate-vigorous physical activity (MVPA) and sleep) to establish links with chronic diseases is a contemporary topic. Little research has looked at the effects of 24-hour movement behaviour on bone health (particularly bone mineral density (BMD)) despite investigation on other health parameters.

The aim of this rapid narrative review was to build on previous work published on the association between SB and BMD in older adults by investigating the association of the more holistic 24- hour movement behaviours in relation to BMD.

Methods: A database search of Web of Science and NIH PubMed was conducted using broad MeSH terms (older adults, sedentary, and bone). Searches were limited from the year 2019 onward.

Results/Discussion: Five published articles were reviewed, and there are discrepancies amongst the findings which could be attributed to the different measurement methods (Peripheral Quantitative Computed Tomography (pQCT) versus Dual-energy X-Ray Absorptiometry (DEXA)) and the sites of measured BMD. There are also notable differences between genders, with BMD in men appearing to be most reliant on time spent in MVPA, compared to women who appear to see benefit to BMD with replacement of SB with LPA and not require more time spent in MVPA. This highlights the complexity of movement behaviours and requires further research.

Introduction

As we live in an aging population, where those over 60 years is predicted to be nearly double in 2050 compared to 2015[1], the health implications of our modifiable lifestyle behaviours have become more apparent. There is strong evidence of the benefits of leading a physically active lifestyle[2] and in recent years, there is further evidence which identifies the additional detriment being sedentary has. This includes the increase in non-communicable diseases[3,4] and contribution to reduced cognitive functioning[5]. However, the examination of sedentary behaviour (SB) on bone mineral density (BMD) (a proxy indicator of bone health) in an older population has been relatively scarce until recently. Our systematic review[6] highlighted only seven articles that had investigated the association between SB and BMD in older adults (age ≥ 65y), of which there was limited longitudinal evidence[7,8] with more cross-sectional studies[9-13]. The results suggested there were gender differences between males and females; with females seemingly having a more

positive association between SB and BMD whilst in males there was either no association found or, in some cases, a negative association was observed[6]. It has been suggested by Rodriguez-Gomez[12] that the reason for differences in associations between studies and across genders might lie in the 24-hour movement behaviour of people; i.e. what other movement behaviours, such as light physical activity (LPA) and moderate-vigorous physical activity (MVPA), people engage in that might also impact on the association between SB and BMD.

Movement behaviours are often investigated in isolation; however movement behaviours are complex and exist on a continuum[14], indicating that an increase in time spent in one behaviour reduces time spent in another[15]. Recent reviews have examined the literature of the reallocation of movement behaviours and the impact this has on health parameters. The evidence emerging suggests that reallocating SB to either LPA or MVPA has positive health effects in all ages[16]. In addition, older adults who participate in more MVPA over the 24-hour period exhibit a reduced risk of mortality and improved mental health[14]. Rollo et al.[14] conducted a review on 24-hour movement behaviours on health across the lifespan. Of the studies included in that review, only one investigated the composition of 24-hour movement on bone health[17]. This study by Taylor[17] focused on the infancy to pre-school aged group (aged 1-5 years), highlighting the lack of literature on the composition of 24-hour movement on bone health, not only in older adults but the adult population as a whole.

Referring back to our own systematic review[6], only one article included explored the composition of 24-hour movement of SB and PA on bone health[12], therefore the aim of this rapid narrative review is to summarise the literature since 2019 on the composition of 24- hour movement in relation to older adult BMD.

Methods

As there is very little research that specifically focuses on BMD and 24-hour movement behaviours in older adults (people over the age of 65y) and BMD, we elected to perform a rapid narrative review of the literature. We conducted a search on Web of Science (core collection) and NIH PubMed; these databases were chosen due to being specialist databases for science, public health and medicine. Broad MeSH terms were used to search the literature using the key words “older adults”, “sedentary”, and “bone”. The searches were limited from the year 2019 onward. The classical intensity bands using count-based threshold: SB (<1.5 METs), LPA (1.5–2.99 METs) and MVPA (≥ 3 METs) were used. Older adult-specific cut-off points for vector magnitude (VM) counts per minute were used in this analysis[18-20]. Articles were reviewed based on their relevance to the above aims.

Results and Discussion

Compositional Analysis in Movement Behaviours

Over a 24-hour period, we perform a number of different movement behaviours, but how do all these movement behaviours throughout the day impact our health? Compositional analysis in regards to PA, SB, sleep and health has been a relatively recent research interest, with Chastin et al.[21] in 2015 using compositional analysis to investigate the combined impact of movement behaviours on cardio-metabolic markers and obesity. This novel analytical method allows for a better understanding of how time distribution during the waking day influences a health outcome. Physical activity, SB and sleep are referred to as co-dependent behaviours, because participating in one results at the expense of the others. Pair-wise log-ratio variances indicate that sleep and SB are the closest co-dependent (0.148) behaviours, sleep and LPA being the second closest co-dependent (0.168) behaviours, and sleep and MVPA being the furthest co-dependent behaviours (1.077)[21]. When investigating the co- dependency of SB and PA (LPA and MVPA), there was a further co-dependency when it comes to SB and LPA (0.248) and MVPA (1.285) compared to sleep co-dependency with PA[21]. The results indicated that time spent in SB and LPA was detrimental for a number of cardio-metabolic markers (e.g., blood pressure and high density lipoprotein), whereas MVPA was beneficial, with LPA being ‘more positive’ compared to SB.

Movement Behaviours and Bone Health in Older Adults

Now there is an understanding of the relationships between all movement behaviours and the effects of time spent in each behaviour has on cardio-metabolic markers, but what is the impact on bone health? As mentioned previously, Rodriguez-Gomez et al.[12] was one of the first studies to investigate 24-hour movement behaviours and BMD indices in 87 older adults from the Toledo Study for Healthy Aging, a Spanish population based prospective cohort study involving men and women over 65 years of age. Similar relationships between SB, LPA and MVPA were found in this study (e.g., SB and MVPA having the furthest co- dependency) to the Chastin et al.[21] study. Results from the Rodriguez-Gomez et al.[12] study indicated that when looking at the whole sample (i.e., both men and women) the combined effect of all movement behaviours (PA and SB) was significantly associated with whole body, leg and femoral region BMD ($p \leq 0.05$).

The results however are not unequivocal and some studies have reported varying results in regard to relative movement behaviours on BMD. Moradell et al.[15] employed a similar 24-hour compositional approach but reported no statistically significant association between any movement

behaviours and BMD. They did, however, find that MVPA was positively associated with cortical thickness of the tibia (assessed by pQCT) in older Spanish adults.

Longitudinal studies that investigate 24-hour movement behaviours on bone health have recently been published[22,23]. The same research group lead by Rodriguez-Gomez et al.[22] followed up the Toledo Study for Healthy Aging older participants over 4 years and reported that there were positive associations with increased time in MVPA relative to other movement behaviours on leg BMD. They also investigated, in the same cohort, the relative changes in movement behaviours on BMD related to the changes to frailty levels over time Rodriguez-Gomez et al.[23]. Those individuals who had positive frailty changes had significantly positive associations between leg, lumbar and femoral BMD ($p = 0.02$; $p = 0.02$; $p = 0.01$, respectively) with increased time spent in MVPA, whereas time in LPA relevant to other movement behaviours appears to have a significant reduction in femoral neck BMD changes ($p = 0.02$). No associations in changes to BMD relevant to overall movement behaviours were reported for those in the no change frailty subgroup or the negative change frailty subgroup[23].

24-Hour Movement, Bone Health and Gender

There was emerging evidence of distinct gender differences when it came to the association between SB and BMD[6]. SB appeared to have a positive association on BMD in older women, whereas there was no or negative association in older men[6]. This conundrum could be explained when looking at the different pattern of activities men and women do during a 24-hour period. For example, the longitudinal study by Rodriguez-Gomez[22] revealed that in men, the type of activity most influential to bone was time spent in MVPA (positive associations with leg and lumbar BMD ($p \leq 0.05$) while SB and LPA had no influence on BMD. In contrast, women seemed to have positive associations between LPA and femoral neck and wards triangle BMD ($p \leq 0.05$). The authors concluded that as older women tend to spend more of their time during the day in LPA type of activities (e.g., household activities, walking), they might decrease their fracture risk by reducing SB and substitute it with LPA types of activity.

Why do results vary?

The above review highlights the differences between genders, but again, also highlights a number of difficulties of generalising the effects of movement behaviours on BMD. One of the challenges is that BMD, as assessed by DXA scans, is reported for a number of anatomical positions (e.g., femoral neck, lumbar spine, leg) and thus direct comparison between results from studies might be difficult. In addition, other studies might report bone health by means of a different imagining technique e.g., pQCT as in the Moradell et al.[15] study, and that also renders the direct comparison of results between studies impossible.

However, what is emerging quite consistently from the recent literature is there are district differences between men and women as far as their 24-hour physical activity behaviour is concerned (i.e., the relative proportion of the day they spent in SB/LPA/MVPA) and that this has a direct effect on their bone health and thus, consequently, on their fracture risk[22,23]. It appears that longer bouts of MVPA type of activities, more often routinely performed by men, facilitate the enhancement of BMD possibly via increases in gravitation force which promotes bone health[24]. These significant associations remain after the compositional behaviour models are adjusted for common confounders (such as age, gender, education, marital status, income, BMI, fat mass, lean mass, alcohol intake, smoking, nutritional status, frailty, common related diseases - arthritis- and calcium intake)[22]. As such reducing or maintaining time spent in SB and LPA and increasing MVPA appears to be the optimal approach to produce improvements in the bone rate of bone mass decay in older men.

However, to gain a better understanding of the context of movement behaviours such as MVPA relative to other activities, it might be beneficial to record the types of activities performed, rather than just use total time spent on MVPA, as obtained from accelerometry.

On the other hand, in older women, MVPA seems to play less of an important role, but this could still be due to the much reduced amount of time in MVPA that women spend (making associations difficult to explore), or that LPA is enough of a stimulator for bone health. In women, decreasing SB, increasing LPA, and maintaining MVPA appears be the best model to enhance bone mass over time. It should be noted though, that the majority of the published data on BMD and 24-hour movement has been reported by one specific research group (Rodriguez-Gomez et al.) with their primary data coming from just one cohort of older participants (Toledo study) and thus caution should be taken when extrapolating these results to the general population.

Additionally, there could be an added component to the 24-hour movement that is more difficult to measure and consider. This is the postural changes of sit-to-stand. Whilst there is little published on this regarding bone health, there is some evidence to suggest frequent standing up may be more beneficial than long uninterrupted periods of sitting when it comes to mortality rates[25] and glycaemic control[26]. We also see improvements in physical function with increased breaks in SB, without a reduction in total SB or increase in LPA or MVPA, in older people in sheltered housing[27]. As such from a public health perspective,

another consideration is sedentary breaks (how many per day, how often, for how long) and sedentary bouts. It has been reported that older women may benefit more from shorter sedentary bouts when it comes to spine BMD[28], but the possible effect of this strategy has not been tested widely and thus requires further investigation.

Conclusion

The interest in the effects of 24-hour movement behaviours on bone health is relatively novel and evidence is still scarce. This narrative update on our previous review[6], focusing more on movement behaviours as a composite over a 24-hour period, provides further evidence, yet also demonstrates the complexity of the behaviours on bone health. There is still no clear indication which daily pattern of movement (what exact relative proportions of SB/LPA/MVPA and sleep over the 24-hour continuum) is more beneficial/detrimental for BMD in older adults. When we investigate further into genders, this is even more unclear, with certain behaviours (e.g., higher levels of MVPA relative to SB) being more beneficial for men in comparison to women where other behaviours seem to be beneficial (a reduction in SB and increased in LPA) for women. When we look at the evidence for impacts of movement behaviours on physiological (e.g., cardio-metabolic) and psychological health, there is accumulating evidence to support the notion that SB is detrimental and MVPA (and more recently LPA) is beneficial, however the research is still sparse when it comes to bone health particularly in older adults and thus this area requires further investigation.

Conflict of Interest

The authors have no conflicts of interest to declare.

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