INFLUENCE OF HIP AND KNEE OSTEOARTHRITIS ON DYNAMIC POSTURAL CONTROL PARAMETERS AMONG OLDER FALLERS

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**Objective:** To compare the relationship between postural control and knee and hip osteoarthritis in older adults with and without a history of falls.

**Methods:** Fallers were those with \( \geq 2 \) falls or 1 injurious fall over 12 months. Non-fallers were volunteers with no falls in the past year. Radiological evidence of osteoarthritis with no reported symptoms was considered “asymptomatic osteoarthritis”, while “symptomatic osteoarthritis” was defined as radiographic osteoarthritis with pain or stiffness. Dynamic postural control was quantified with the limits of stability test measured on a balance platform (Neurocom® Balancemaster, California, USA). Parameters assessed were end-point excursion, maximal excursion, and directional control.

**Results:** A total of 102 older individuals, mean age 73 years (standard deviation 5.7) years were included. The association between falls and poor performance in maximal excursion and directional control was confounded by age and comorbidities. In the same linear equation model with falls, symptomatic osteoarthritis remained independently associated with poor end-point excursion (\( \beta \)-coefficient (95\% confidence interval) \(-6.80 (-12.14 \text{ to } -1.42) \)).

**Conclusion:** Poor performance in dynamic postural control (maximal excursion and directional control) among Fallers was not accounted for by hip/knee osteoarthritis, but was confounded by old age and comorbidities. Loss of postural control due to hip/knee osteoarthritis is not a risk factor for falls among community-dwelling older adults.

Key words: aged; osteoarthritis; accidental falls; dynamic postural control; lower limb.

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One-third of individuals aged 65 years and half of those aged 80 years and above fall annually (1–3). Fall-related injuries are leading causes of years lived with disability globally (4). Falls in older adults are multifactorial. Established risk factors for falls include increasing age, muscle weakness, balance impairment, visual loss, hearing impairment and cognitive decline (5). Serious consequences associated with falls in older adults include hip fractures, traumatic brain injuries, institutionalization, depression and premature death (6, 7).

Radiological changes consistent with severe osteoarthritis (OA) of the knee are present in 30\% of individuals aged 75 years or above (8). The presence of OA is associated with balance deficits and impaired dynamic postural control compared with individuals without OA (9–15). The loss of balance associated with OA has been attributed to the symptoms of pain and stiffness (16, 17). A previous uncontrolled study reported that 50\% of individuals with severe OA experience at least 1 fall in the previous year (18). Based on the above circumstantial evidence, OA has been considered a risk factor for falls in older adults.

While it would appear likely that falls occur in older adults with OA as the result of loss of postural control attributed to the symptoms of OA, this hypothesis has, however, not been substantiated by published evidence. Therefore, the aim of this study was to evaluate the role of OA in deficiencies in postural control observed among older adults with falls.

**METHODS**

**Participants**

Fallers were subjects 65 years and above and with 2 falls or 1 injurious fall over the past 12 months, recruited from the Departments of Emergency Medicine, Primary Care and Geriatric Medicine, in a teaching hospital in Kuala Lumpur, Malaysia, for a randomized controlled study on multifactorial interventions (Malaysia Falls Assessment and Interventional Trial, MyFAIT) (19). Control participants consisted of older volunteers (aged \( \geq 65 \) years) with no history of falls over the past 12 months, recruited through media and word-of-mouth advertising. Participants from both case (fallers) and control (non-faller) groups received detailed baseline assessments to obtain information on socio-demographics, medical history and medications. This study complied with the Declaration of Helsinki 1975. It was approved by the University of Malaya Medical Centre Medical Ethics Committee (approval number 925.4). Written informed consent was obtained from all study participants.

**Assessment of dynamic postural balance**

Each participant was tested with 3 established groups of balance tests, using a long force-plate balance platform (Neurocom® Balancemaster, Natus Medical Incorporated, Pleasanton, CA, USA). The balance platform uses a fixed 18" x 60" dual-force plate to measure the vertical forces exerted through the participant’s feet.
Influence of hip and knee OA on postural control

RESULTS

A total of 102 subjects (60 fallers and 42 non-fallers) were recruited for the study. Fallers were significantly older than non-fallers, and significantly more likely to report a pre-existing diagnosis of diabetes mellitus. There was no significant difference in the presence of radiologically diagnosed hip or knee OA between fallers and non-fallers (Table I). Significantly lower MXE \( (p=0.023) \) and DCL \( (p=0.031) \) scores were present in fallers compared with non-fallers. No significant difference was observed in EPE \( (p=0.185) \) between fallers and non-fallers.

Within-group comparisons of postural control

Table II displays the EPE, MXE and DCL scores between the 3 categories: symptomatic OA, asymptomatic OA, and non-OA, within the 2 main groups of fallers and non-fallers. Among fallers, there was no significant difference in EPE, MXE or DCL during 3-way comparisons using ANOVA between the symptomatic OA, asymptomatic OA and non-OA groups. Among non-fallers, significant differences were present in EPE, MXE, and DCL. Using pairwise comparisons with post-hoc LSD, EPE, MXE and DCL were significantly different between the symptomatic OA and asymptomatic OA groups, as well as non-OA and symptomatic OA groups. No significant difference in EPE, MXE or DCL was observed between non-fallers with asymptomatic OA and non-fallers without OA (Table II).

Table I. Baseline characteristics of participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Fallers (n=60)</th>
<th>Non-fallers (n=42)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years, mean (SD)</td>
<td>74.54 (6.07)</td>
<td>70.71 (4.66)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sex, female, n (%)</td>
<td>46 (80.7)</td>
<td>31 (68.9)</td>
<td>0.246</td>
</tr>
<tr>
<td>Ethnicity, n (%)</td>
<td></td>
<td></td>
<td>0.081</td>
</tr>
<tr>
<td>Malay</td>
<td>10 (17.5)</td>
<td>18 (40.0)</td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>35 (61.4)</td>
<td>21 (46.7)</td>
<td></td>
</tr>
<tr>
<td>Indian</td>
<td>11 (19.3)</td>
<td>5 (11.1)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>1 (1.8)</td>
<td>1 (2.2)</td>
<td></td>
</tr>
<tr>
<td>Body mass index, kg/m², mean (SD)</td>
<td>24.75 (4.48)</td>
<td>24.83 (4.38)</td>
<td>0.926</td>
</tr>
<tr>
<td>Comorbidities, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart disease</td>
<td>1 (1.7)</td>
<td>1 (2.4)</td>
<td>0.807</td>
</tr>
<tr>
<td>Hypertension</td>
<td>34 (57.6)</td>
<td>19 (45.2)</td>
<td>0.219</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>25 (42.4)</td>
<td>6 (14.3)</td>
<td>0.003</td>
</tr>
<tr>
<td>Stroke</td>
<td>3 (5.1)</td>
<td>0 (0.0)</td>
<td>0.264</td>
</tr>
<tr>
<td>Radiological OA*, n (%)</td>
<td>51 (85.0)</td>
<td>29 (69.0)</td>
<td>0.640</td>
</tr>
<tr>
<td>Groups, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-OA</td>
<td>8 (13.3)</td>
<td>7 (16.7)</td>
<td>0.640</td>
</tr>
<tr>
<td>Symptomatic OA</td>
<td>42 (70.0)</td>
<td>27 (64.3)</td>
<td>0.544</td>
</tr>
<tr>
<td>Asymptomatic OA</td>
<td>10 (19.0)</td>
<td>8 (16.7)</td>
<td>0.756</td>
</tr>
<tr>
<td>Dynamic postural parameters mean (SD)</td>
<td>51.03 (14.36)</td>
<td>55.38 (13.75)</td>
<td>0.129</td>
</tr>
<tr>
<td>End-point excursion</td>
<td>51.03 (14.36)</td>
<td>55.38 (13.75)</td>
<td>0.129</td>
</tr>
<tr>
<td>Maximal excursion</td>
<td>65.02 (17.61)</td>
<td>72.62 (14.48)</td>
<td>0.023</td>
</tr>
<tr>
<td>Directional control</td>
<td>57.27 (13.88)</td>
<td>62.91 (11.09)</td>
<td>0.031</td>
</tr>
</tbody>
</table>

OA: osteoarthritis; SD: standard deviation.

*Hip or knee. Bolded numbers indicate significance at p-value < 0.05.
When we entered both falls and symptomatic OA into the same linear regression equation in Model G, symptomatic OA was independently associated with poorer EPE regardless of the presence of falls, and remained significant after adjustment for confounders (Model P; OR –6.80, 95% CI –12.14 to –1.42). Falls, on the other hand, were independently associated with worsening MXE (Model H; OR –7.34, 95% CI –13.88 to –0.81) and DCL (Model I; OR –5.42, 95% CI –10.58 to –0.32) independent of symptomatic OA, but these associations were no longer significant after adjustments for age and diabetes mellitus in Model Q (OR –4.47, 95% CI –11.12 to 2.19) and Model R (OR –3.79, 95% CI –8.64 to 1.05), respectively (Table III).

### DISCUSSION

This study demonstrates that, while among older individuals with no known history of falls in the preceding year, postural control is influenced by symptomatic hip and knee OA, this relationship does not exist among older individuals with a history of 1 injurious fall or 2 or more falls. While older fallers have significantly poorer postural control in MXE and DCL compared with non-fallers, this relationship is confounded by symptomatic OA.

#### Table III. Linear regression on the association of poor postural control, falls and symptomatic osteoarthritis (OA) (n=102)

<table>
<thead>
<tr>
<th></th>
<th>Non-OA (n=60)</th>
<th>Symptomatic OA (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>End-point excursion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted Models</td>
<td>Model A</td>
<td>Model B</td>
</tr>
<tr>
<td>Falls</td>
<td>–4.35 (–9.98 to 1.29)</td>
<td>–7.60 (–14.15 to –1.06)</td>
</tr>
<tr>
<td>Symptomatic OA</td>
<td>–7.34 (–13.16 to –1.52)</td>
<td>–5.42 (–10.58 to –0.32)</td>
</tr>
<tr>
<td>Adjusted Models*</td>
<td>Model J</td>
<td>Model K</td>
</tr>
<tr>
<td>Falls</td>
<td>–7.09 (–12.89 to –1.29)</td>
<td>–9.59 to 1.30</td>
</tr>
<tr>
<td>Symptomatic OA</td>
<td>–6.75 (–12.11 to –1.40)</td>
<td>–5.42 (–9.17 to 1.56)</td>
</tr>
</tbody>
</table>

*Adjusted for age and diabetes mellitus. Bold font indicates significance at p < 0.05.

Models A to F: unadjusted models with falls or symptomatic OA as independent variables. Models G to I: unadjusted models with falls and symptomatic OA as independent variables. Models J to O: falls or symptomatic OA as independent variables adjusted for age and diabetes mellitus. Models P to R: falls and symptomatic OA as independent variables adjusted for age and diabetes mellitus.
increasing age and comorbidities, but not by symptoms of OA. Furthermore, symptomatic OA among older adults was significantly associated with poorer EPE, which was not associated with falls. The current study therefore suggests, rather controversially, that, while OA does affect dynamic postural control in older individuals, the impairments in dynamic postural control that exist among older fallers are not attributable to OA symptoms. In addition, the loss of postural control found in individuals with OA is not associated with increased risk of falls.

Postural stability is a complex and interactive system in the human body. With increasing age, the ability to maintain the body’s COG over the base of support in a given sensory environment reduces, and this usually occurs as a result of an accumulation of physical deficits (26). Previous studies have shown that subjects with knee OA swayed significantly more while standing than control subjects in both lateral and anteroposterior directions (11, 17, 27, 28). Few studies have, however, evaluated dynamic postural control among individuals with OA, or evaluated the effects of OA on dynamic control among older fallers (27). Furthermore, the literature behind the relationship between OA and falls has been conflicting (29). We measured dynamic postural control on a balance platform that assesses directional control, EPE and maximal excursion. These measures are expected to reflect the individual’s ability to maintain their stability while performing activities of daily living. While impaired dynamic postural control is expected to increase the risk of falls, the actual occurrence of falls is also dictated by the likelihood of the individual exceeding their limits of stability. This may not occur if the individual has good awareness of their limitations and is equipped with compensatory mechanisms to overcome their deficits.

Within the control group in our study, we were able to demonstrate distinct differences in dynamic postural control performance between those with symptomatic OA and those with asymptomatic OA as well as those with no OA. This result is in concordance with the previous findings that showed OA symptoms affected dynamic postural control (9, 12, 17, 27). In contrast, while postural control was impaired among fallers compared with non-faller controls, the presence of OA regardless of symptoms was not associated with any changes in the limits of stability among the fallers in the current study, despite there being similar numbers of fallers with radiological OA. This suggests the possibility that the presence of OA does not influence dynamic postural control among older individuals with recurrent falls. Alternatively, as it is well established that falls occur due to the presence of multiple risk factors, therefore fallers universally have impaired dynamic control, which may occur due to numerous risk factors (30).

Our previous study has suggested that radiological OA subjects with mild symptoms had a lower risk of falls compared with those with asymptomatic OA (31). Within our present study, while non-fallers with asymptomatic OA had better dynamic postural control than non-fallers with symptomatic OA in both within- and between-groups comparisons, this relationship was not observed among fallers. This would again support our previous hypothesis that individuals with radiological changes consistent with OA in the absence of OA symptoms were more likely to take risks, as they were unaware of their joint limitations. However, it is also possible that fallers with asymptomatic OA are falling due to other risk factors.

In the multivariate analyses, the significant association between impaired dynamic postural control (MXE and DCL) and falls was confounded by age and comorbidities. As individuals who are older with comorbidities such as diabetes mellitus also had an increased likelihood of developing OA, the extent to which diabetes mellitus, age and OA individually influence falls risk remains unclear (32, 33). The consistency of the relationship between symptomatic OA and EPE even after adjustment, however, suggests that a poorer EPE score was not due to old age or comorbidities. Since EPE measures the distance travelled by the COG on the “primary attempt” to reach the target, a poorer EPE score is related to balance strategies. We therefore postulate that falls do not occur, despite the presence of knee joint pain or stiffness, due to effective compensatory strategies adopted by the individuals with OA; for instance, by taking more time and avoiding body positions which compromise their stability (34, 35). Furthermore, the individuals with symptomatic OA, DCL and MXE remained relatively intact, while in fallers, DCL and MXE were impaired during unadjusted analysis. The pattern of loss of postural control in individuals with symptomatic OA is therefore different from the pattern of postural control impairment observed in fallers.

In essence, this study challenges previous assumptions that OA was associated with increased risk of falls as a result of loss of dynamic postural control (36, 37). In fact, as increasing age and the presence of comorbidities are also associated with other established falls risk factors, including dementia and polypharmacy, and these were not assessed in this study, it is possible that the loss of dynamic postural control observed in fallers only leads to falls in the presence of other established risk factors, which have yet to be elucidated.
Study limitation

A selection bias was introduced because the study excluded fallers who had difficulty performing the tests on the balance platform, and these fallers probably represented the individuals with the worst balance scores. However, we had specifically selected subjects who were at high risk of future falls by including only those individuals with injurious or recurrent falls, and excluding individuals with one fall without injury. The current study only took into account the presence of knee and hip OA. OA affecting the spine or feet is also expected to affect postural control, but this was not assessed in this study.

Conclusion

The pattern of loss of postural control observed in symptomatic hip or knee OA was a reduction in EPE, while loss of maximal excursion and directional control were associated with increased risk of recurrent or injurious falls. Furthermore, the impairment in postural control observed among fallers was not attenuated by the presence of symptomatic OA in multivariate analysis. The findings of the current study therefore challenge previous assumptions that lower limb OA is linked with falls via reduced dynamic postural control. It is likely that older individuals with recurrent and injurious falls developed impaired dynamic postural control due to a variety of mechanisms, including OA. However, additional risk factors, which have yet to be elucidated, are required to sustain an actual fall event.

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The authors declare no conflicts of interest.

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Influence of hip and knee OA on postural control


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