PLANTAR PRESSURE DIFFERENCES BETWEEN LOW-RISK AND HIGH-RISK KNEE OSTEOARTHRITIS RUNNERS: A PRELIMINARY STUDY

Phillis Soek Po Teng[1], Ryan Jun Kai Tan[1]

Physical Education and Sports Science Academic Group, National Institute of Education, Nanyang Technological University, Singapore[1]

Little is known about the biomechanical factors that predate knee osteoarthritis (OA) for high-risk recreational participants. This study aims to investigate if plantar pressure differences exist between low and high-risk knee OA runners. Fifteen male recreational runners participated in a preliminary study and were divided into low-risk (N = 8) and high-risk (N = 7) knee OA groups. Both groups ran 100 metres thrice in both indoor and outdoor settings at a comfortable pace. Participants' plantar pressure was measured. No significant differences in plantar pressure between low-risk and high-risk knee OA runners were found. Future studies may consider employing a better representation of high-risk knee OA runners and use radiographic techniques for a more accurate classification.

KEYWORDS: knee OA, KOOS, early detection

INTRODUCTION: Knee osteoarthritis (OA) is a common musculoskeletal disease, and its incidence rates will likely see an increase as the worldwide population ages and obesity rates rise. However, there is currently a lack of data, particularly in Asia, to understand the biomechanical factors that predate and result in knee OA (Leung et al., 2013). There is therefore a need to diagnose knee OA early to delay its onset, especially at a relatively earlier age (Leung et al., 2013). A change in plantar pressure distribution was reported with knee OA (Saito et al., 2013), but data for people with high-risk and early knee OA were not collected. He et al. (2022) did not compare knee OA with normal participants to determine if a change in plantar pressure predates the onset of knee OA. A previous study on high-risk and early knee OA participants of the general population was conducted (Teng et al., 2023). Results showed that plantar pressure distribution for early OA participants was significantly higher than that of normal and high-risk participants in the lateral aspect of the mid and forefoot during walking. This suggests that plantar pressure could potentially serve as an early diagnostic tool for early knee OA detection. Driban et al. (2017) has further stipulated that sports participation, even amongst recreational athletes, may increase knee OA risks developing later in life. Yet, sport players have not been the focus of many of the existing knee OA research. Therefore, the aim of this preliminary work was to study the difference in plantar pressure between high and low-risk knee OA recreational athletes, using recreational runners in this preliminary study.

METHODS: This study was performed with the approval of the Nanyang Technological University Institutional Review Board (IRB-2023-323). Fifteen male recreational runners were recruited. The inclusion criteria were that participants were aged between 21 to 50 years, English speaking, heel-strike recreational runners that did not exceed a weekly running distance of 25 kilometres and have not participated in a competitive running event in the past year. The participants did not have injuries to the lower extremities in the last six months; history of surgery to the lower extremities in the last three years; medical history of autoimmune arthritis; symptoms of active arthritis (e.g., gout); symptoms of severe knee OA (e.g., swelling, severe pain when bending the knee etc.,); and any other medical conditions which would prevent safe participation in the study. All participants were informed of the experimental procedures and written consent was obtained prior to conducting the study. The classification into the high-risk knee OA group was based on meeting any of the following criteria: overweight Body Mass Index (BMI) of ≥ 23.0kg/m^2; average KOOS of less than 90, based on the result of the previous study (Teng et al., 2023); any knee pain in the last six months; or any first-degree relatives with a medically diagnosed arthritic condition. The demographic data of both groups

are presented in Table 1. Age, height, and weight were not found to be significantly different using the Mann-Whitney U test (α = 0.05).

Table 1: Demographics of both low-risk and high-risk knee osteoarthritis (KOA) groups

Group	N	Age (years)	Height (m)	Mass (kg)	BMI (kg/m^2)
Low-Risk KOA	8	23.8 ± 1.4	1.7 ± 0.1	63.9 ± 11.2	20.8 ± 1.7
High-Risk KOA	7	24.0 ± 0.8	1.7 ± 0.1	68.3 ± 6.1	22.8 ± 1.3

Participants warmed up for five minutes with a slow jog, and then ran at 11.5 km/h indoors and at a comfortable pace outdoors, both with a score of between four to six on the Borg scale of perceived exertion (CR10) (Borg, 1982). A total of three separate readings of the participants' plantar pressure over a running distance of 100 metres indoors on a treadmill, and another three separate readings over the same running distance outdoors, were recorded for each participant. The order of indoor and outdoor running was randomised. Each participant was provided with the same standardised pair of running shoes (Adults Aquashoes 100, Decathlon, France). Plantar pressure measures were taken using the Moticon insole sensors (Moticon ReGo AG, Munich, Germany). The plantar pressure data was sampled at 100Hz and the maximum average plantar pressure for each sensor in indoor and outdoor settings were then used for data analysis. For high-risk participants who have indicated the side with knee pain, plantar pressure analysis was based on the affected knee. For the rest, analysis was carried out based on the average of both left and right knees. Data analyses were conducted using the SPSS software (Version 28.0 — IBM Corp., NY, USA). Plantar pressure comparisons between the low-risk and high-risk knee OA groups were conducted using the Mann-Whitney U test using α = 0.05.

RESULTS: There were no significant differences ($p > 0.05$) in average maximum plantar pressure across all regions of the feet (Figure 1) for both indoor (Figure 2) and outdoor (Figure 3) running between the low-risk and the high-risk knee OA groups. Relatively higher average maximum pressure was observed in the big toe region (sensor 14) and lower in the arch region (sensor 7) for both indoor and outdoor running (Figures 2 and 3).

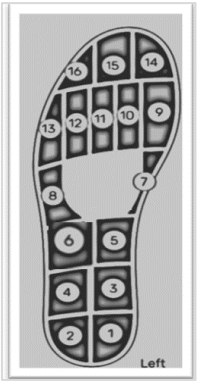

Figure 1: Sensor positions on the insole

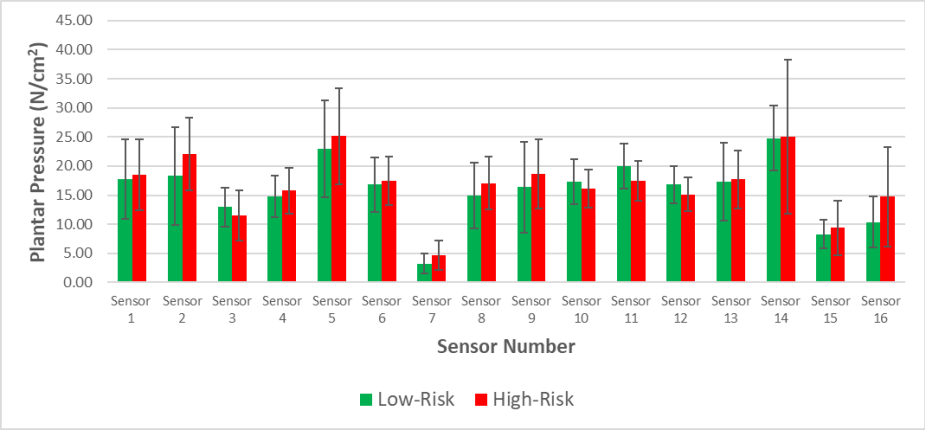

Figure 2: Plantar pressure measurements between low and high-risk knee osteoarthritis runners during indoor running (mean ± standard deviation)

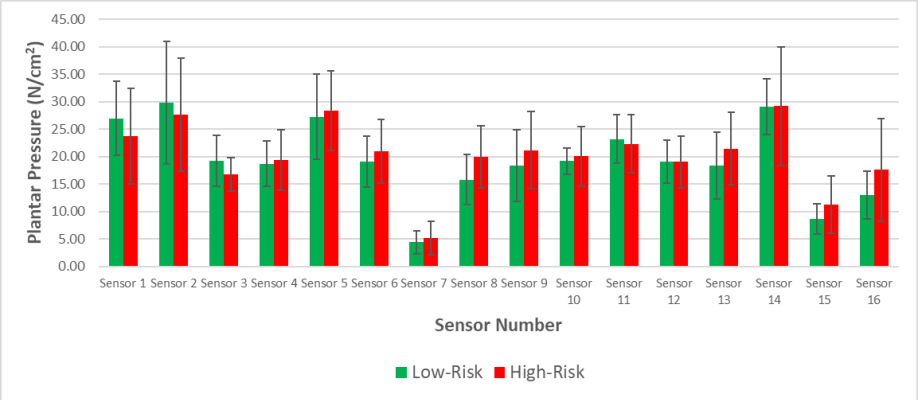

Figure 3: Plantar pressure measurements between low and high-risk knee osteoarthritis runners during outdoor running (mean ± standard deviation)

DISCUSSION: To the best of our knowledge, the study was the first to investigate plantar pressure differences between low and high-risk knee OA recreational runners. The average maximum plantar pressure measurements between two groups were not significantly different as hypothesized. This was unlike our previous study result for the high-risk and early knee OA participants from the general population during walking ((Teng et al., 2023)). Other studies investigating plantar pressure also found different plantar pressure measurements between individuals with knee OA and healthy individuals (Saito et al., 2013) or across knee OA severities (He et al., 2022). The lack of significant differences in plantar pressure in this study could be attributed to a few reasons. Firstly, for simplicity of this preliminary study, common risk factors such as BMI, knee pain, genetic risk factors and the KOOS were used to distinguish between low-risk and high-risk knee OA groups. This may not be stringent enough to correctly categorize these runners into low and high-risk groups. Future studies could also incorporate radiographic images of the participants' knees to allow for better classification based on the Kellgren & Lawrence scale. Also, the age for the high-risk knee OA group in the present study was 24.0 ± 0.8 years whereas the mean age of knee OA participants in Saito et al.'s (2013) and He et al.'s (2022) study were 75.0 years and 61.4 years respectively. Knee OA is a degenerative disease that deteriorates over time. The lack of significant plantar pressure differences could simply be because our younger participants have not already exhibited any risk factors of knee OA yet. Lastly, studies have also suggested that recreational runners could have a lower chance of developing knee OA than competitive runners and controls (Alentorn-Geli et al., 2017, Jandacka et al., 2024). A more competitive cohort of runners could be used as targeted participants in future instead. Pressure trends between indoor and outdoor running across sensors were also similar, with relatively higher pressure at the big toe and lower

pressure at the arch. This suggests that in future, running in either on the treadmill or outdoors is sufficient to study pressure trends. The current study has certain limitations. Firstly, the sample size is small and a bigger sample size with better classification into low and high-risk knee OA participants is required to confirm the results. Another limitation was that the running speed outdoors was not constant in the present study across participants. This might confound the plantar pressure results as running speed affects plantar pressure (Ho et al., 2010). However, even at the same running speed on the treadmill, there was still no difference in plantar pressure between the two groups. Future studies could also control for running speed. Also, a sampling rate of 100 Hz was used, as recommended by Mann et al. (2016). Future studies could use a higher sampling frequency such as 200 Hz (Burnie et al., 2023), considering higher frequency components around ground contact during running.

CONCLUSION: Plantar pressure between low-risk and high-risk knee OA runners were not found to be significantly different in this preliminary study. However, given the lack of studies looking at knee OA and and plantar pressure when running, future studies could build on the current work to determine if plantar pressure differences could indeed be used to distinguish between low and high-risk knee OA runners. It is recommended that the future studies also use a more stringent classification of runners into low-risk and high-risk groups and recruit a more representative pool of athlete runners for study.

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