



Evaluation the Association between Adduction Moment and Pain in Subjects with Knee Osteoarthritis: A Systematic Review of Literature

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ABSTRACT

Background: There is no doubt that the number of subjects with knee Osteoarthritis (OA) is increasing. Most of the subjects with knee OA have functional limitations due to pain. However, in most research studies on knee OA and investigation of the influence of various treatment interventions, the magnitude of adductor moment has been used to represent the severity of OA and the effects of interventions. However, the main question posed here is that is there any association between pain and adductor moment in the knee joint. Therefore, this study aimed to investigate the association between knee pain and adduction moment. **Method:** This was a systematic review in which, a search was done in some databases including PubMed, ISI web of knowledge, Embase, and Scopus for a period between 1960 and 2020. Some keywords such as knee pain, orthosis, wedge, rehabilitation, exercise were used in combination with knee pain and adduction moment. The quality of studies was evaluated by the Pedro scale. **Results:** 21 papers were selected for final analysis with quality varied between 6 and 9. 9 papers focused on both adduction moment and pain without any intervention, 2 papers on the effect of using a brace on knee adduction moment and pain, 6 papers on the use of exercise on knee pain and moment and 4 papers on influence of insole on knee pain and adduction moment. **Conclusion:** Although most investigators claim that there is a positive association between adduction moment and pain, this correlation is controversial. Therefore, it is recommended to determine the association between these parameters in a big study.

Keywords: Adduction moment, Pain, Knee osteoarthritis

INTRODUCTION

The incidence of knee osteoarthritis varies between 14% and 18% of the total population in various countries [1]. Those subjects should use various treatment approaches to decrease their pain and to improve their functional performance [2-4]. There is no doubt that the subjects with knee OA suffer from knee pain and limitation in the range of motion of the knee joints [5,6]. Based on the results of various research studies, the loads applied to the knee joints play a significant role to increase the symptoms of knee OA [7]. It has been shown that knee adduction moment is the primary determinant of the loads applied on the medial part of the knee (the force applied on the medial part of the knee joint is two times more than that on the lateral side) [6-10]. Moreover, the correlation between adduction moment and severity of OA based on KL grade has been approved [11,12].

There is no doubt that the main problem associated with knee OA is a pain especially during walking [13]. Most people with symptoms of knee OA have been visited by clinicians due to pain. However, it is controversial that those with high knee OA severity and knee pain have an increase in adduction moment compared to normal subjects [14-18].

In most of the available studies, the suitability of various treatment approaches (rehabilitation interventions) has been evaluated based on their influences on joint adduction moment [2,19-21]. It means that, if the adduction moment applied on the joint decreased following the intervention, it has been concluded that the use of a treatment approach will reduce knee pain and functional limitations.

It has been mentioned that those with knee OA decrease their walking speed to decrease the loads applied on the knee joint during walking which finally may decrease the pain [15,22]. However, the efficiency of most therapeutic interventions, such as knee offloading braces, wedges, and physical therapy exercise was evaluated based on knee

adduction moment (this is a parameter used to represent joint loading in most available studies) and severity of pain. In most of these studies, it was confirmed that an increase in joint loading increases the severity of knee OA which finally increases knee pain. However, when the severity of knee pain decrease follows the use of therapeutics intervention, walking speed will be increased which finally increases the loads applied on the knee joint [23]. Bennell, et al. showed that hip adduction strengthening exercise decrease knee pain while walking with no significant effect on knee moment [24,25]. Therefore, it is controversial whether there is a direct and significant correlation between the severity of OA (based on adduction moment) and pain or not. Therefore, this review article aimed to determine the association between pain and adduction moment in the patients with knee OA, based on the relevant literature. The main hypothesis was that there is a direct correlation between knee adduction moment and knee pain. The output of this study will help the clinicians and researchers to select an appropriate parameter to decrease the progression of knee OA and to determine the efficiency of various treatment approaches.

METHOD

An electronic search was done *via* PubMed, Google Scholar, Embase, Ebsco, and ISI web of knowledge databases from 1960 to 2020. Some keywords such as knee pain, orthosis, wedge, rehabilitation, exercise were used in combination with knee pain and adduction moment.

In the first step, the papers were selected based on titles and abstracts to address the research questions of interest. In the second step the papers were selected based on the following criteria:

- The paper was published in English
- Include both knee pain and adduction moment

Type of Studies

The emphasis of this study was to focus mostly on randomized control trials; however, due to the lack of these studies on this topic other types of studies were also included. Abstracts, conference articles, editorial comments, and expert opinions were excluded from the final list.

Type of Participants

The studies focused on participants with knee OA were selected in this study.

Type of Interventions

The studies on the use of conservative treatment were selected in this study. Conservative treatments include bracing, casting, resting, and exercise. The studies focused on surgery or comparison between surgery and conservative treatment were excluded from the review.

Type of Outcomes

The main outcome measures selected in this study include pain and knee adduction moment.

Secondary outcome: No other parameters were selected as secondary outcomes.

Selection of the Studies

Two researchers independently screened the studies based on the aforementioned criteria. It was done mostly based on titles and abstracts.

Data Extraction and Management

This review was done based on PICO (Population, Intervention, Comparison, and Outcomes) style. It means that the data of each study was categorized as population, intervention, comparison, and outcomes.

Quality Assessment and Determination of the Risk of Bias

The quality of the studies was evaluated based on the Pedro tool. It is a reliable tool to evaluate the quality of the studies.

RESULTS

52 papers were obtained based on the mentioned keywords. Finally, 21 papers were selected for final analysis, in which 9 papers focus on knee adduction moment and pain (without any intervention), 2 papers on the effect of using a brace on knee adduction moment and pain, 6 papers on the use of exercise on knee pain and moment and 4 papers on influence of insole on knee pain and adduction moment. The quality of studies varied between 6 and 9. In most of the mentioned studies, the severity of knee OA was evaluated by K.L grade. The severity of knee pain during walking was represented by WOMAC and VAS scores.

Tables 1-5 show the number of subjects, procedure, outcome, and quality of the studies selected in this study. As can be seen from the results of the research presented in tables, 9 studies confirm a positive correlation between knee pain and adduction moment, in contrast, 5 studies represent a reverse correlation between the severity of pain and knee adduction moment. The other studies could not represent any correlation between the knee adduction moment and pain.

Table 1 The results and quality assessment scores of the studies reported knee adduction moment and pain in subjects with knee OA

Reference	Subject	Method	Outcome	Quality (11)
[26]	36 healthy subjects (18 men and 18 women). 192 OA divided into two grade based on KL-less sever KL grade <2 and sever KL grade >2 Less sever: age=62.1 ± 5.9 Weight=98.5 ± 12.2 Sever: age=63.9 ± 7.1 Body weight= 104.7 ± 15.6	KOOS was used to measure pain severity. A Vicon system with 6 cameras and a Kistler force plate was used.	This study showed that knee pain may be induced in healthy volunteers to significantly reduce the adduction and sagittal plane knee joint moment during walking.	8
[27]	79 subjects (42 male, 37 female) Age=60.2 ± 9.8 years Height=1.69 ± 0.08 Mass=79.2 ± 13.5 kg Subjects used sophisticated shoes, which their sole was 1.3-1.5 times stiffer on the lateral side than on the medial side.	Osteoarthritis changes were monitored by MRI findings. Pain severity was scored by use of WOMAC. A Qualisys motion analysis system with 8 cameras was used. The subjects were followed for 6 months.	The results of this study showed that variable stiffness shoes can effectively reduce the peak of adduction moment for 6 months. The mean values of pain decreased which followed by an increase in functional performance.	7
[28]	62 subjects (30 female, 32 males) Age=62 ± 10 years The subjects had Kellgren and Lawrence grades of at least 1. WOMAC scale was used to score pain.	An optoelectric system with passive retro-reflective markers and a force plate was used in this study. The static alignment of the knee was also scaled based on an X-ray.	There was a negative correlation between the WOMAC subscores and knee moment. However, there was a correlation between the mechanical axis and moments applied on the knee joint.	9
[22]	100 subjects (men and women) Aged >50 years with the painful medial side of the knee.	The pain was scored based on a 100 mm visual analog scale. The severity of OA was scored based on KL grade. Subjects were received various exercises to decrease pain and loads on the knee joint. Motion analysis system was done by use of 12 cameras and two force plates.	This research was to compare the efficiency of neuromuscular exercise and traditional knee exercise on reducing knee pain and moments of the knee joint however, no correlation was reported.	7

Table 2 The results and quality assessment scores of the studies reported knee adduction moment and pain in subjects with knee OA

References	Subject	Method	Outcome	Quality (11)
[17]	25 female with symptomatic bilateral medial knee OA Age=62 ± 7 Mass=77.2 ± 9.99 kg	The pain was scored by WOMAC. Knee severity was scored by use of the KL scale. The alignment of the leg was monitored by X-ray. A Vicon motion analysis system with 8 camera and two force plates were used to monitor the subjects. A biomechanical intervention was used in this study.	Knee adduction moment impulse, 1st, and 2nd KAM peaks were reduced significantly. Moment reductions were accomplished by an increase in walking speed, and reduce in pain severity.	5
[14]	9 patients with knee OA Age=67.8 ± 5 Mass=74 ± 12.3	In this paper, the effects of local knee joint analgesia were discussed based on loads and pain severity. Pain severity was scored by use of WOMAC.	Following injection pain during walking decreased followed by an increase in joint loads.	7
[29]	10 patients with knee OA participated in this study.	Pain level was assessed using 11 points visual analog scale. The performance of the subjects was evaluated while walking with a novel knee brace.	The knee adduction moment decreased by 48 % following the use of orthosis. The severity of knee pain decreased after 3 months follow the use of orthosis.	7
[30]	11 patients with unilateral OA in the medial knee compartment Age=55.5 ± 5.5 years Mass=79.8 ± 14.3	The severity of pain was analyzed by use of WOMAC. A motion analysis system consisted of 8 cameras and 1 force plate was used.	A significant difference between the second peak of adduction moment while walking with and without orthosis. A Significant decrease occurred while walking with orthosis based on pain score.	6
[16]	10 subjects with OA, and severity more than 1 Age=60 ± 13 Height=1.71 ± 0.09 Mass=79.8 ± 14.3	The effects of 6-week exercise on knee pain and adductor moment were evaluated. WOMAC questionnaire was used to assess the knee pain and function. A Vicon system with 8 cameras and a force plate was used to record the motion. The severity of OA was expressed by KL grade.	It has been shown that gait retraining reduces the KAM, reduces pain, and improves function in subjects with knee OA.	6

Table 3 The results and quality assessment scores of the studies reported knee adduction moment and pain in the subjects with knee OA

References	Subject	Method	Outcome	Quality (11)
[12]	75 subjects with knee OA (47 men and 28 women) Age=66.4 years (± 9.8) Mean weight=79.6 ± 13.2	The pain was measured using a modified hospital for a special surgery pain rating system. Gait was analyzed using 4 cameras Qualisys and a force plate. Multiple regression analysis was used to check the association between pain and adduction moment.	No correlation was found between adduction moment and pain.	6
[31]	53 subjects (30 male and 23 female) with knee pain and X-ray evidence of medial tibiofemoral were included in this study. The average age, height, and mass were 61 ± 10 years, 177 ± 9 cm and 85 ± 11 kg for men and 63 ± 10 years, 163 ± 8 cm, 69 ± 9 kg for women. Knee OA severity was between 1 and 4. Knee pain was scored based on a 50 score.	A motion analysis system was used to determine the moments applied on the knee joint. Knee joint severity was monitored by KL grade.	There was a significant inverse correlation between the change in the adduction moment and the change in the pain.	9

[32]	36 subjects with knee OA (28 female, 8 male), age=54.88 ± 7.74	The subjects were divided into two groups (1) received 3 mm lateral wedge (2) received 7 mm lateral wedge. The severity of OA was determined by KL grade. The pain was scored by use of the western Ontario MC Master questionnaire (WOMAC).	There was no difference between pain scores before and after the use of a 3 mm lateral wedge. But the effect of 7 mm was significant.	8
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Table 4: The results and quality assessment scores of the studies reported knee adduction moment and pain in the subjects with knee OA

References	Subject	Method	Outcome	Quality (11)
[33]	10 normal and 10 subjects with knee OA. Age=68 ± 11	The severity of OA was based on KL grade. WOMAC questionnaire was used to record knee pain. A motion analysis system with 6 cameras and two force plates was used to collect the data.	There was a significant difference between the walking velocity of normal and OA subjects. Moreover, there was a significant correlation between walking speed and hip extensor moment.	7
[25]	89 patients with knee OA. The effects of hip strengthening on knee load and pain were evaluated.	The pain was reported by use of 11 points scale. The severity of knee OA was evaluated by use of 11 points scale. A motion analysis (Vicon) with two force plates was used.	Strengthening of hip muscles decreases pain and improves the performance of OA subjects; however, it did not affect the loads on knee OA.	6
[24]	88 men and women with knee OA over 50 years old. The effects of hip strengthening on loads applied on knee OA were evaluated.	The severity of knee OA was scored by use of KL grade. The pain was scored by use of 11 points score. The motion of the knee joint was collected by the use of a Vicon motion analysis system with 8 cameras and two force plates.	Hip strengthening has the potential to reduce knee adduction moment and slow down disease progression.	6
[34]	73 elderly subjects with and without knee pain (age=75.2 ± 6.5)	The knee adduction moment was measured during standing; chair rise walking and stair descend.	Subjects with chronic knee pain had higher adduction moments with locomotor activities.	6
[35]	42 patients with bilateral knee OA. There was also a group of control matches. Age=65.2 ± 12.5 Control=61.7 ± 12.3	Pain severity was scored by WOMAC. The severity of OA was scored based on KL grade.	Gait changes related to medial compartment knee OA depend on the severity of the disease. Following heel strike maximum adduction moment at hip and knee joints were increased in all patients with knee OA.	7
[36]	108 patients with various severity of OA.	Knee OA was scored by use of KL grade. The pain was scored by use of WOMAC score. The motion was scored by use of Qualisys system with 4 cameras and a Kistler force plate. The alignment of the knee was scored based on an X-ray.	There was a significant correlation between knee pain and the magnitude of knee adduction moment.	7

Table 5 The results and quality assessment scores of the studies reported knee adduction moment and pain in the subjects with knee OA

Researcher	Subject	Method	Outcome	Quality (11)
[37]	40 patients with age above 50 with knee OA were recruited in this study.	Knee joint loads were evaluated while walking with and without the 5-degree lateral wedge. The motion was analyzed by a Vicon system with a 6 camera and two force plates. Static alignment was measured based on X-ray. The pain was scored by WOMAC.	This research showed that the use of the lateral wedge insole decreases both pain and load.	7
[38]	40 individuals with medial knee OA (age=62.98 ± 9.73) participated in this study.	Home strengthening program used for hip abductor for 8 weeks. Knee alignment was checked based on X-ray.	The hip strengthening program improves the hip abductor but does not affect on knee adduction moment. The pain of the knee during walking decreased and functional performance increased.	6
[39]	Two groups of subjects participated in this study. 40 with knee OA (11 female, 29 male). Control group with age 51 ± 9.99.	KL grade was used to calculate the severity of knee OA. The severity of pain was scored by use of WOMAC. Motions were captured using an onto-track system and an AMTI force plate.	The subjects used a mechanism that improves walking speed, decreases loads and pain.	6

DISCUSSION

The incidence of knee osteoarthritis is increasing especially in elderly subjects. There is no doubt that those with knee osteoarthritis suffer from limitation in knee joint range of motion, pain during walking, and high energy consumption [5,6]. It has been shown that the progression of knee OA is dependent upon the loads applied on it, in which the knee adduction moment plays a significant role [7,14]. Most of the subjects with knee OA are referred to clinicians due to their pain while walking. However, the effectiveness of most of the treatment approaches used for those with OA was evaluated based on knee adduction moment. It is controversial whether the decrease in pain is associated with a reduction in knee adduction moment or not. Therefore, it was aimed to evaluate the correlation between knee adduction moment and pain, based on the available literature.

As can be seen from tables 1 and 2, 18 papers evaluated both severities of knee pain and adduction moment. The quality of most of them was acceptable since the number of participants was high. However, the available literature was divided into 5 groups:

- General research on knee moment and pain
- Effect of exercise on knee moment and pain
- Effect of knee orthoses on knee pain and moment
- Effect of shoe insoles on knee pain and moment
- Effect of injection on knee pain and moment

General Biomechanical Studies

9 studies evaluated knee moment and pain. The quality of them varied between 6 and 8. Four papers represent a positive correlation, 3 papers found no significant correlation and 2 papers found a negative correlation between knee adduction moment and pain [2,12,17,22,25-29].

The study done by Skwara, et al. focused on elderly subjects with and without knee pain however in research of

Munderman, et al., and Hasanzad, et al., subjects with knee OA were selected [35,40,41]. It should be mentioned that pain is the result of increasing the loads applied to the joint. It means that an increase in loads applied on the knee will eventually lead to an increase in OA and pain.

Some studies show a positive correlation between knee pain and OA [2,24,26,27,29,33]. They claimed that those with knee pain decrease their walking speed and therefore the applied moment will decrease. It means that pain decreases the ability of the subjects, therefore they cannot increase their walking speed. Based on these studies, it can be concluded that pain relief in OA subjects decreases the loads applied on the knee.

From the above-mentioned studies, it is not easy to find a direct or indirect correlation between knee pain and knee OA severity. However, since the quality of the studies which emphasize positive correlation is high it can be concluded that there may be a positive correlation between knee pain and OA severity and adduction moment.

The second group of papers was those which measured both knee pain and adduction moment while walking with the orthosis and or insole. 5 studies were evaluating the effect of foot insole on pain and adduction moment [31]. Moreover, there were two studies on the use of knee orthoses [2,29]. The quality of these studies varied between 6 and 7. The most important point is that in all of these studies decrease in adduction moment is associated with a reduction in knee pain while walking.

The interesting point is that in the research done by Hinman, et al. on the effect of using insole on knee pain and adduction moment, it has been reported that use of insole neither influence on knee adduction moment nor effects on knee pain [37]. The main reason which can be mentioned for this change is that subjects with a decrease in knee pain will have more abilities to walk. Therefore, an increase in walking speed will influence the applied force on the leg and finally increase the adduction moment. There were, also some studies that focus on the effect of exercise on loads of the knee joint and knee pain [15,22-25]. The quality of these studies varied between 6 and 7. In the research done by Bennell, et al. on 100 elderly subjects, no results were reported on the effects of neuromuscular exercise and traditional knee exercise on reducing knee adduction moment [22]. In the research done by Sled, et al. and Bennell, et al. on the effect of hip abduction strengthening exercise on the knee load, it has been shown that knee pain decreased without any significant effect on knee adduction moment [23,25].

From the above-mentioned studies, it can be concluded that the correlation between the loads applied on the knee joint, based on adduction moment, and pain is controversial. It means that it cannot be concluded that if the loads applied on the knee joint decreased follow various treatment interventions, the severity of pain will be decreased simultaneously. Although adduction moment has been used exclusively to represent the efficiency of treatment approaches, it is not an indicator of knee pain severity.

The output of this systematic review showed that the correlation between knee pain and adduction moment is controversial. It means that it cannot be concluded that a decrease in knee pain is associated with a decrease in knee joint loading. The outputs of this study help clinicians and researchers to select appropriate parameters to determine the efficiency of various treatment approaches. Based on the results of this review a decrease in knee pain may not show that the loads on the knee joint decreases and incidence of knee joint OA will be decreased. Due to the lack of information in this regard, it is recommended to do a study with a big number of subjects with knee OA to evaluate the association between knee pain and knee joint loading based on adduction moment. The output of this study will help the researchers and clinicians to select appropriate parameters to determine the efficiency of various treatment interventions.

CONCLUSION

In most of the studies done on knee joint biomechanics, adduction moment was used to represent the load applied on the knee joint. It was assumed that there would be a positive correlation between adduction moment and pain. However, based on the available literature it is controversial whether the increase in adduction moment is associated with an increase in knee pain or not.

DECLARATIONS

Conflicts of Interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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