

DISCUSSION PAPER
CUMULATIVE JOINT TRAUMA
IN THE DEVELOPMENT OF OSTEOARTHRITIS OF THE
LUMBAR SPINE, HIPS, KNEES and ANKLES

Entitlement should not be claimed for Cumulative Joint Trauma alone. Entitlement, for VAC purposes, should be claimed for Osteoarthritis, with the affected joint identified (see Entitlement Eligibility Guideline on Osteoarthrosis/Osteoarthritis).

INTRODUCTION

“Cumulative joint trauma” in this paper means physical trauma to a specific joint of the lumbar spine, hips, knees, or ankles from an increased load which occurs over a period of time following a repetitive activity, in the absence of an identifiable injury to that joint.

This discussion examines how repetitive cumulative joint trauma may influence the development of osteoarthritis (OA) in normal joints, anatomically abnormal joints, and injured joints of the lumbar spine and lower extremities, i.e. the weight-bearing joints. It excludes overuse injury to soft tissues.

A number of variables influences the relationship between cumulative joint trauma and OA of the weight-bearing joints. OA is a disease that evolves over a period of time, and is associated with the natural process of aging. Its development can be influenced by a variety of factors, including obesity, congenital joint abnormalities, and incidents of direct injury or trauma.

PLEASE NOTE: This discussion should be read in conjunction with the entitlement guideline on Osteoarthrosis/Osteoarthritis. An application for pension entitlement for OA requires that a “disability” from OA be present. For VAC pension purposes, a “disability” from OA is demonstrated when relevant signs and/or symptoms are present. X-ray evidence alone is insufficient to demonstrate a disability, as the condition must be symptomatic. X-ray findings do not correlate well with symptoms of OA ; therefore, while it is accepted that osteophytes and joint space narrowing are signs of OA, they do not mean that OA is symptomatic.

PATHOPHYSIOLOGY IN OSTEOARTHRITIS

OA is a disease that begins in the articular cartilage but eventually involves the surrounding tissue, bone and synovium. When the cartilage is absent from the articular surface, the underlying bone is subjected to greater local stresses. Remodelling of the bone occurs at the joint margins through the formation of osteophytes, and can be considerable.

After the initial stages of cartilage degeneration (from many causes, including injury), there may be a delay of many years before a person feels joint pain or an x-ray shows osteoarthritic changes. Significant cartilage damage may have occurred before relevant signs and symptoms appear.

OA is a common disease, with more than 75% of individuals over 70 years of age showing some definite radiographic evidence of OA. The exact prevalence of OA at various ages depends upon the radiographic measures used. Any critical evaluation of the literature on the effect of cumulative trauma and the development of OA needs to address whether radiographic scoring methods were used to evaluate the radiographs, and what criteria have been used for diagnosis and grading of OA. The American College of Rheumatology has developed criteria for x-ray classification of OA, which is widely used in diagnosis and treatment decisions. The AMA Guides to The Evaluation of Permanent Impairment, 5th edition, state:

“Certain roentgenographic findings that are of diagnostic importance, such as osteophytes and reactive sclerosis, have no direct bearing on impairment. The best roentgenographic indicator of disease stage and impairment for a person with arthritis is the cartilage interval or joint space. The hallmark of all types of arthritis is thinning of the articular cartilage; this correlates well with disease progress.”

Progression of OA on x-ray, however, does not necessarily mean that there is or will be a worsening of symptoms.

It should be noted that there are known inconsistencies between findings on x-rays and clinical symptoms, with only 50% to 60% of subjects with radiographic OA being clinically symptomatic. Further, an absence of x-ray evidence of OA does not exclude the presence of the disease, particularly in the early stages (Lane & Buckwalter, 1993).

Bearing in mind that, for VAC pension purposes, symptomatic OA is required as evidence of a “disability” resulting from OA, there are several points which should be made:

1. While the presence of osteophytes is an early indication of OA, osteophytes are not a good predictor of symptomatic OA.
2. While the presence of joint space narrowing is an indication of OA, joint space narrowing is not a good predictor of symptomatic OA.

3. Progression of OA on x-ray does not mean that there is or will be a worsening of symptomatology.

A number of risk factors has been implicated in the *pathogenesis of OA generally*, including but not limited to:

1. age
2. gender
3. ethnicity
4. biochemical, e.g. bone density
5. genetics
6. local biomechanical factors, e.g.
 - obesity
 - cumulative joint trauma*
 - specific joint injury**
 - joint deformity
 - muscle weakness
 - ligamentous laxity of joint
7. inflammation, e.g. bacterial joint infection

*It has been suggested that repetitive minor impact loading causes an above average frequency of OA in the joints of competitive athletes and members of certain occupational groups. The sites noted as being affected are the ankles of ballet dancers and the knees of basketball players. Occupational groups which may be affected include any trade involved in vehicle/aircraft maintenance, weapons loading and firing, infantry trades where heavy loads are carried on the person, unloading/loading of vehicles, and unloading of pallets and storing of their contents.

**In a prospective cohort study of 1321 young adults to examine the risk for knee and hip OA associated with joint injury during young adult life, findings strongly demonstrated that adolescents and young adults with traumatic injury to the knee joint, as well as persons with knee and hip injuries incurred during middle age, are at substantially increased risk for OA at the same joint later in life (Gelber).

More specifically, a scientific conference held on July 23-24, 1999, at the National Institutes of Health [NIH] identified the following apparent risk factors for *post traumatic* OA:

1. high body mass
2. high level of activity
3. residual joint instability or malalignment
4. persistent articular surface incongruity

And further, Lane and Buckwalter, 1993, have identified the following as *possible risk factors in cumulative trauma-induced OA*:

1. biomechanical factors, e.g. joint malalignment, obesity
2. biochemical factors, e.g. bacterial joint infection
3. age
4. gender
5. characteristics of the playing surface
6. duration and intensity of the particular sport
7. any history of joint injury

PATHOLOGICAL EFFECTS OF CUMULATIVE TRAUMA ON MUSCULOSKELETAL TISSUE

The explanation for why injured or biomechanically abnormal joints result in accelerated degeneration is related to an understanding of how repetitive loading and motion affect the musculoskeletal tissues.

Although the muscle, bone, cartilage, tendon, and ligament tissues of the skeletally mature individual and specific structures formed from these tissues may not appear to change over time, they are degraded and replaced throughout life. If replacement balances degradation, the composition and volume of the musculoskeletal tissue remain constant. A persistent imbalance progressively changes the composition and, sometimes, the volume of the tissue forming a specific joint.

Adjustment or adaption of tissues to persistent increases or decreases in stresses and strains in the tissue can influence the development of the musculoskeletal system. Adaptation of tissues to increased loading makes possible the increases in the tissue strength necessary for athletic activities and rehabilitation of tissue disruption or degeneration. Adaptation of tissues to decreased loadings decreases tissue strength and increases the probability of mechanical failure. As athletic conditioning improves muscle strength, prolonged bed rest is well known to result in tissue wasting and atrophy.

LITERATURE REVIEW

Until recent years, there were no prospective controlled clinical studies examining the effects of physical activity on musculoskeletal disability. Many retrospective studies, however, have been conducted. These suggest a possible relationship between physical activities and OA. The literature review below summarizes the findings of various types of studies.

The Framingham cohort study enrolled “elderly” white men and women in 1948 to 1952.

The OA component of the study commenced in 1983 with questions regarding musculoskeletal disease and radiography of bilateral hands and anteroposterior knees. At 10 year follow-up, in 1992-93, 869 individuals received follow-up knee radiography. Hand radiographs were also obtained and represented a 25 year follow up to those obtained in 1967-69. Sons and daughters of the original cohort and spouses of these sons and daughters were x-rayed in 1993-94 at a mean age of mid-50's. Weight-bearing knee x-rays and hand radiographs were obtained on all subjects. Major findings include the following:

1. That symptomatic knee OA (defined as pain on most days plus positive findings on x-ray of the symptomatic knee) occurs in 6.1% of the Framingham adult population ages 30 and over. Symptomatic hip OA occurs in 0.7-4.4% of adults.
2. That symptomatic knee OA occurs in 9.5 percent of persons aged 63-94, with a higher prevalence in women: 11.4% for women and 6.8% for men.
3. That weight loss reduces the risk for symptomatic knee OA in women.
4. That obesity or as yet unknown factors associated with obesity cause knee OA, and that the link is stronger in women than men.

Felson, Hannan, et al (1991) conducted an analysis of the Framingham study. They simultaneously controlled for the potential confounding variables of age, body mass index, history of knee injury, attained education, and average number of cigarettes smoked. The analysis led to four conclusions:

1. That joint space narrowing is not a good predictor of symptomatic knee disease.
2. That osteophytes are not a good predictor of symptomatic knee disease.
3. That joint space narrowing is associated with knee bending accompanied by medium to very heavy physical occupational demands* in men.
4. That there is a statistically significant association between the presence of osteophytes and occupations requiring knee bending with at least a moderate level of physical activity in men when compared with those in sedentary occupations.

**The 5 degrees of physical demand are as follows: sedentary (10 lbs maximum, only occasional walking or standing); light (20 lbs maximum with frequent lifting or carrying of up to 10 lbs; walking or standing frequent); medium (50 lbs maximum with frequent lifting or carrying of up to 25 lbs); heavy (lift 100 lbs maximum with frequent lifting or carrying of up to 50 lbs); very heavy (lift over 100 lb maximum with frequent lifting or*

carrying objects over 50 lbs).

Another analysis of OA and physical activity from the Framingham study data was published by Hannan et al in 1993. The authors concluded that regular exercise may influence the development of osteophytes, but not increase the risk of symptomatic or more severe knee OA in men or women. The number of subjects was large (1,415), and the period of follow-up was 36 years. Possible confounding variables such as age, body mass index, knee injury, smoking and education were taken into account. The length, size, and prospective nature of this study cause it to be very highly regarded amongst major epidemiological studies. The mean age of the participants at the endpoint of the investigation was 73 years, an age by which any activity-related OA would be likely to have manifested itself. In addition, subjects were asked to grade their activity into five separate levels and state how many hours they spent on each. This ensured consideration of activities of both occupation and recreation, and also provided a more sensitive measure of total activity than merely assigning subjects to occupational or sporting categories.

Lane and Buckwalter, 1993, concluded that normal joints in individuals of all ages appear to tolerate prolonged and vigorous exercise without adverse consequences or accelerated development of OA. However, it was considered probable that the development of OA will be accelerated in individuals who have underlying anatomical abnormalities (such as quadriceps muscle weakness and anatomic variances, like varus deformity of the knees and leg-length discrepancy) who engage in significant amounts of exercise that stress the lower extremities. It was suggested that if anatomic variances of the hip, knee, or ankle are found and cannot be remedied easily by a heel lift or a foot orthosis, these individuals should change their sports activities to avoid future joint degeneration. Further, individuals who have suffered injuries of supporting structures (like ligaments, tendons, or menisci) may have accelerated development of OA in weight-bearing joints, even without increased stress to the joint from exercise. These individuals should be encouraged to engage in non-weight-bearing activities like swimming or stationary bicycling to maintain cardiovascular fitness and musculoskeletal conditioning.

The findings of a much smaller population-based case-control study (109 patients) by Cooper et al , 1994, showed an increased risk of radiographic knee OA in those subjects whose occupation involved more than 30 minutes per day squatting, or kneeling, or climbing more than ten flights of stairs per day. The authors adjusted for obesity and Heberden's nodes. They concluded that the data suggested that prolonged or repeated knee bending is a risk factor of OA, and that the risk may be higher in jobs which entail both knee bending and mechanical loading.

Two cross-sectional studies have examined hip OA in runners. Puramen et al , 1978, found that former champion distance runners had no more clinical or radiographic OA than non-runners. Marti et al, 1989, however, found more radiographic changes of degenerative hip disease in former national distance running champions than in bobsled

competitors and controls. Lane and Buckwalter, 1993, have interpreted these two cross-sectional studies as demonstrating that high intensity, high mileage running should not be dismissed for premature OA of the hip.

Puramen's findings were corroborated by a cross-sectional study entitled "Long-Distance Running, Bone Density and Osteoarthritis" reported in JAMA, 1986. This study was comprised of 41 long distance runners aged 50-72 years, who were compared with 41 matched community controls to examine associations of repetitive, long-term physical impact from running with OA and osteoporosis. X-rays of hands, lateral lumbar spine, and knees were assessed without knowledge of running status. A computed tomographic (CT) scan of the first lumbar vertebra was performed to quantitate bone mineral content. Runners were found to have approximately 40 percent more bone mineral than matched controls. There were no differences between groups in joint space narrowing, crepitation, joint stability, or symptomatic OA. While running was found to be associated with increased bone mineral, it was not found to be associated with clinical OA.

Lane and Buckwalter indicate that cross-sectional studies of the effect of weight bearing exercise on the development of OA of the hip, knee, ankle, and foot should be interpreted with caution because the radiographic scoring methods that each group of researchers has used are not the same. This information is important when the major endpoints in the studies are radiographic features of OA.

Of note is the large Vingard et al, 1991, Swedish register-based cohort study which involved 250,000 subjects from the 1980 census. All subjects were in blue-collar occupations. Each subject reported the same occupation for the census years of 1960, 1970 and 1980, i.e. 20 years. This study looked at risk of hospitalization for OA of the hip and knee in the various occupations. It showed as follows:

1. That male farmers, construction workers, firefighters, and some food processing workers had an excess risk of hospitalization for OA of the hip.
2. That male farmers, construction workers and firefighters had an increased risk of hospitalization for OA of the knee.
3. That female mail carriers had an excess risk of hospitalization for OA of the hip.
4. That female cleaners had an excess risk of hospitalization for OA of the knee.

Weaknesses of this study include an inability to control for possible confounders, such as major trauma and obesity. Further, the study was anonymous and none of the subjects was interviewed. The authors urged further epidemiological studies with improved work histories and individual assessment of exposure.

A 1952 study by Lawrence and Aitken-Swan, and Kellgren and Lawrence, of British coalminers in their 40's demonstrated significantly more radiological changes of lumbar disc degeneration, and possibly more OA of the knees, than either manual or office workers. A significant association between these radiological changes and attacks of pain in the lumbar sciatic distribution and in the knees was demonstrated. The miners also showed more arthritic changes in other joints, such as the elbows and hips.

A Finnish study (Kujala et al, 1994) which looked at hospital admissions for OA of former elite athletes, supported the hypothesis that heavy sport training over many years could lead to OA. In this study, however, no attempt was made to adjust for incidents of major trauma, such as meniscus injuries.

A conference of the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), part of the National Institutes of Health (NIH), held in July 1999 and published in the Annals of Internal Medicine, Oct. 2000, addressed occupational factors in respect of the risk for OA. Following is a summary of several conclusions with respect to occupational factors:

1. Some studies have shown that workers whose jobs involve physical labour have high rates of knee OA.
2. Farmers have high rates of hip OA.
3. Once specific job tasks were examined, jobs requiring kneeling or squatting along with heavy lifting were associated with especially high rates of both knee and hip OA. Forces across the knee increase when in the crouching or squatting position. Lifting loads from such a position further increases loading. Turning while performing this activity provides additional torsional stress. It was noted that data from the Framingham study suggests that such job activities cause anywhere from 15% to 30% of knee OA in men.
4. Other occupational activities, including climbing stairs, walking on uneven ground, standing and sitting have been inconsistently linked to OA risk (site unspecified).

The NIH (NIAMS) conference of July 1999 also addressed sports participation in respect of the risk for OA, and concluded:

1. Moderate regular running has a low, if any, risk of leading to OA (site unspecified).
2. Sports activities that appear to increase the risk for OA (site unspecified) include those that demand high-intensity, acute, direct joint impact as a result of contact with other participants, playing surfaces, or equipment. Examples include

injuries to the knees of football players and of soccer players.

3. Repetitive joint impact and torsional loading (twisting) appear to be associated with joint degeneration, as seen in the knees of soccer players.

The authors of the NIAMS conference summarized their conclusions as follows:

1. Weight loss can reduce the risk of knee OA. In one major study cited by the review, those individuals who lost 11 pounds, cut their risk in half.
2. Weakness of the quadriceps muscle is common in persons with OA of the knee. It is clear that strengthening the quadriceps can help. (A relatively small increase in strength, 20 percent for men and 25 percent for women, can lead to a 20-30 percent decrease in risk of OA).
3. There is a low risk, or no additional risk, of knee OA from regular, moderate running. However, sports that involve high-intensity, acute, direct joint impact from contact with other players, playing surfaces or equipment even in the absence of discrete joint injury do have an increased risk of knee OA, as in the knees of football players. Sports that involve both repetitive joint impact and twisting also have an increased risk of knee OA, as in the knees of soccer players. The authors suggest that individual counselling, rule changes, changes in equipment and playing surfaces, and training can help reduce cumulative trauma injuries. Early diagnosis, treatment, and complete rehabilitation from actual discrete joint injuries can decrease risk of subsequent knee OA.
4. 15-30 % of the knee OA in men is attributable to occupational activities, particularly jobs requiring kneeling or squatting in combination with heavy lifting.

An Australian review of the literature with respect to OA and the role of what is termed “multiple microtraumata” determined that it is unlikely that a short period of multiple microtraumata is causally related to the development of OA. However, the Australian Repatriation Medical Authority (RMA) concludes that being occupationally required to undertake *continuous heavy physical activity* for at least 10 years may produce or aggravate OA of the hip, knee or ankle. It defines the occupational requirement to undertake continuous heavy physical work in respect of the hip, knee or ankle as follows:

*“...working in a job requiring continuous and repetitive flexion, extension or twisting of the affected joint, frequent carrying of loads of at least 35 kg, lifting of maximal loads in a twisted or bent position, or exposure to or engagement in, any combination of these activities **on most days**. [Please see definition below]*

Types of employment which may fall within this definition include road worker, bricklayer, storeman, farmer or gardener. However, every case should be

considered individually, as, for example, not all farmers would satisfy the definition and there may be other occupations which may involve the activities described above.”

The RMA has set out different criteria for *continuous heavy physical activity* in respect of the lumbar spine, stating that this means as follows:

“.... working in a job that has high energy demands or requires some measure of physical strength, and engagement in any of the following activities on most days:

(i) repetitive or persistent flexion, extension or twisting of the thoracic/lumbar spine; or

(ii) frequent manual lifting or carrying of loads of at least 25kg with occasional manual lifting or carrying of loads of at least 35kg; or

(iii) frequent manual pushing or pulling of loads of at least 25kg with occasional manual pushing or pulling of loads of at least 35kg.

‘On most days’ can be taken to mean at least 51% of days worked in this occupation. In a military setting such occupations may include working in Stores, Construction, or Vehicle Workshops.”

SUMMARY

The following recommendations are based on the literature search conducted, with its attendant strengths and weaknesses. They are specific to the disease process of OA. They deal with weight-bearing joints, which are the lumbar spine, the hip joints, the knee joints, and the ankle joints.

The question of whether cumulative trauma causes, contributes to, accelerates and/or aggravates OA is far from simple. There are a number of reasons for this, including the nature of the osteoarthritic process, the variety of terminology used to describe “cumulative joint trauma”, and methodological differences in design of studies. To elaborate, OA takes a long time to develop, and is associated with the natural process of aging. It is difficult to measure, as are the amount and types of cumulative joint trauma required to influence OA. There are a number of possible confounding variables in the analysis of the contribution of cumulative joint trauma to OA, and, in some instances, there is insufficient analysis of these variables. (The variables of obesity, joint abnormalities, and direct injury or trauma have been taken into account in the *Recommendations for VAC Pension Purposes* section.) Direct comparison of studies is complicated by the lack of standard radiological and clinical diagnostic criteria for OA; some studies measure OA by clinical findings, and others by x-ray evidence. Other study limitations include an absence of control groups and undue reliance on anecdotal information, in some cases.

The following recommendations are made on the basis of the above-noted literature

review. Each case is to be adjudicated on the evidence provided and its own merits, and in accordance with the legislative provisions, particularly ss. 5(3) and 2 of the *Pension Act*, R.S.C. 1985, c.P-6.

RECOMMENDATIONS FOR VAC PENSION PURPOSES

Please note :

OA can be diagnosed by symptoms or pathology. For VAC purposes, the “disability” of OA is defined by the existence of relevant signs and/or symptoms; x-ray evidence alone is insufficient.

There are several risk factors for OA which have been identified in the literature. For the purposes of this paper, however, only the following risk factors, as defined in the following *Definitions* subsections, are considered in the relationship between cumulative joint trauma and OA:

- obesity
- an anatomically abnormal joint
- a joint that has been affected by specific trauma

The recommendations should be read in conjunction with the entitlement guideline on Osteoarthrosis/Osteoarthritis.

The timeframes required to cause, accelerate or aggravate OA may be shorter if a combination of factors exists.

LUMBAR SPINE:

Definitions:

- *Cumulative joint trauma associated with occupations* means manual lifting or carrying of loads of at least 25 kg with occasional manual lifting or carrying of loads of at least 35 kg; **or** manual pushing or pulling of loads of at least 25 kg with occasional manual pushing or pulling of loads of at least 35 kg.
- *Normal spine* means a spine that is not *anatomically abnormal* or a spine that has not been subject of *specific trauma*, as defined below.
- *Anatomically abnormal lumbar spine* means a lumbar spine that is affected by underlying muscle weakness or imbalances, neurologic abnormalities, or anatomic variations (such as spondylolisthesis of the lumbar spine).

- *Specific trauma* means significant physical injury to a joint, including a fracture involving the intra-articular surface of the joint, surgery, and penetrating injuries from projectiles.
- *Obesity* may aggravate lumbar spine OA.
Obesity means a significant increase in body weight by way of fat accumulation (of the order of a 20% increase in baseline weight), with a BMI of 30 or greater, which have been present for at least 10 continuous years.
$$\text{BMI} = \frac{\text{weight in kgs}}{\text{height in metres squared}}$$

This definition excludes weight gain resulting from edema, peritoneal or pleural effusion, or muscle hypertrophy.

CAUSATION:

1. Cumulative joint trauma associated with occupations in an individual with a normal lumbar spine

For cumulative joint trauma associated with occupations to cause OA in an individual with a normal lumbar spine, the following criteria should be met:

Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 10 years; *and*

Signs/symptoms of OA should be present in the affected part of the lumbar spine during this timeframe or within 25 years after the activity ceases.

2. Cumulative joint trauma associated with occupations in an individual with an anatomically abnormal lumbar spine **or** in an individual with a lumbar spine that has previously sustained specific trauma

*For cumulative joint trauma associated with occupations to contribute to OA in an individual with an anatomically abnormal lumbar spine **or** in an individual with a lumbar spine that has previously sustained specific trauma, the following criteria should be met:*

Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 5 years; *and*

Signs/symptoms of OA should be present in the affected part of the lumbar spine during this timeframe or within 25 years after the activity ceases.

AGGRAVATION:

1. Cumulative joint trauma associated with occupations in a non-obese individual in the aggravation of pre-existing lumbar spine OA

For cumulative joint trauma associated with occupations in a non-obese individual to aggravate OA lumbar spine, the following criteria should be met:

Increased signs/symptoms of OA develop during the activity, or within 30 days of stopping the activity; *and*

Increased signs/symptoms of OA last for a period of at least 6 months, on a continuous or recurrent basis, whether or not the activity has stopped.

2. Obesity may be a factor in aggravation of lumbar spine OA when the criteria set out in the Definitions subsection are met.

Exclusions:

The following activities are not considered activities which would cause OA in a normal lumbar spine or aggravate OA lumbar spine:

- running that is not of high intensity or high mileage
- stairclimbing*
- walking on uneven ground*

*The level and intensity of the noted activities are what is anticipated to occur on an informal basis in daily life.

HIPS:**Definitions:**

- *Cumulative joint trauma associated with occupations* means kneeling or squatting in combination with carrying of loads of at least 35 kg on most days, **or** lifting of 35 kg loads in a twisted or bent position.
- *Cumulative joint trauma associated with sports and/or exercise activities* means high-intensity, acute, direct joint impact as a result of contact with other participants, playing surfaces, or equipment; **or** repetitive joint impact with torsional loading (twisting); **or** running of high intensity and high mileage, as in marathon running or training.
- *Normal hip* means a hip that is not *anatomically abnormal* or a hip that has not been subject of *specific trauma*, as defined below.
- *Anatomically abnormal hip* means a hip that is affected by underlying muscle weakness or imbalances, neurologic abnormalities, or anatomic variations (such

as valgus deformity of the hips, or a mild joint dysplasia).

- *Specific trauma* means significant physical injury to a joint, including a fracture involving the intra-articular surface of the joint, surgery, and penetrating injuries from projectiles.
- Obesity may cause or aggravate bilateral hip OA.
Obesity means a significant increase in body weight by way of fat accumulation (of the order of a 20% increase in baseline weight), with a body mass index (BMI) of 30 or greater, which have been present for at least 10 continuous years.
$$\text{BMI} = \frac{\text{weight in kgs}}{\text{height in metres squared}}$$

This definition excludes weight gain resulting from edema, peritoneal or pleural effusion, or muscle hypertrophy.

CAUSATION:

1. Cumulative joint trauma associated with occupations in a non-obese individual with a normal hip

For cumulative joint trauma associated with occupations to cause OA in a normal hip in a non-obese individual, the following criteria should be met:

Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 10 years; *and*

Signs/symptoms of OA should be present in the affected part of the hip during this timeframe or within 25 years after the activity ceases.

2. Cumulative joint trauma associated with occupations in an obese individual

For cumulative joint trauma associated with occupations to contribute to OA of the hips in an obese individual, the following criteria should be met:

Bilateral hip OA must have developed; *and*

Cumulative joint trauma associated with occupations should have taken place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 5 years; *and*

Signs/symptoms of OA should have been present in the hip joints during this timeframe or within 25 years after the activity ceased.

3. Cumulative joint trauma associated with occupations in an individual with an anatomically abnormal hip **or** in an individual with a hip that has previously sustained specific trauma

For cumulative joint trauma associated with occupations to contribute to OA of the hip in an individual with an anatomically abnormal hip or in an individual with a hip that has previously sustained specific trauma, the following criteria should be met:

Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 5 years; and

Signs/symptoms of OA should be present in the hip joint during this timeframe or within 25 years after the activity ceases.

4. Cumulative joint trauma associated with sports and/or exercise activities in a non-obese individual with a normal hip

For cumulative joint trauma associated with sports and/or exercise activities to cause OA in a normal hip in a non-obese individual, the following criteria should be met:

Cumulative joint trauma associated with sports and/or exercise activities should take place for a total of at least 5 hours per week for a period of at least 10 years; and

Signs/symptoms of OA should be present in the hip joint during this timeframe or within 25 years after the activity ceases.

5. Cumulative joint trauma associated with sports and/or exercise activities in an obese individual

For cumulative joint trauma associated with sports and/or exercise activities to contribute to OA of the hips in an obese individual, the following criteria should be met:

Bilateral hip OA must have developed; and

Cumulative joint trauma associated with sports and/or exercise activities should have taken place for a total of at least 5 hours per week for a period of at least 5 years; and

Signs/symptoms of OA should have been present in the hip joints during this timeframe or within 25 years after the activity ceased.

6. Cumulative joint trauma associated with sports and/or exercise activities in an individual with an anatomically abnormal hip or in an individual with a hip that has previously sustained specific trauma

For cumulative joint trauma associated with occupations to contribute to OA of the hip in an individual with an anatomically abnormal hip or in an individual with a hip that has previously sustained specific trauma, the following criteria should be met:

Cumulative joint trauma associated with sports and/or exercise activities should take place for a total of 5 hours per week for a period of at least 5 years; and

Signs/symptoms of OA should be present in the hip joint during this timeframe or within 25 years after the activity ceases.

AGGRAVATION:

1. Cumulative joint trauma associated with occupations in a non-obese individual in the aggravation of pre-existing hip OA

For cumulative joint trauma associated with occupations in a non-obese individual to aggravate hip OA, the following criteria should be met;

Increased signs/symptoms of OA develop during the activity, or within 30 days of stopping the activity; *and*

Increased signs/symptoms of OA last for a period of at least 6 months, on a continuous or recurrent basis, whether or not the activity has stopped.

2. Cumulative joint trauma associated with sports and/or exercise activities in a non-obese individual in the aggravation of pre-existing hip OA

For cumulative joint trauma associated with sports and/or activities in a non-obese individual to aggravate hip OA, the following criteria should be met;

Increased signs/symptoms of OA develop during the activity, or within 30 days of stopping the activity; *and*

Increased signs/symptoms of OA last for a period of at least 6 months, on a continuous or recurrent basis, whether or not the activity has stopped.

3. Obesity may be a factor in aggravation of bilateral hip OA when the criteria set out in the Definitions subsection are met.

Exclusions:

The following activities are not considered activities which would cause OA in a normal hip joint, or aggravate hip OA:

- running that is not of high intensity or high mileage
- stairclimbing*
- walking on uneven ground*

*The level and intensity of the noted activities are what is anticipated to occur on an informal basis in daily life.

KNEES:**Definitions:**

- *Cumulative joint trauma associated with occupations* means kneeling or squatting in combination with carrying of loads of at least 35 kg on most days, **or** lifting of 35 kg loads in a twisted or bent position.

- *Cumulative joint trauma associated with sports and/or exercise activities* means high-intensity, acute, direct joint impact as a result of contact with other participants, playing surfaces, or equipment; **or** repetitive joint impact with torsional loading (twisting); **or** running of high intensity and high mileage, such as in marathon running or training.
- *Normal knee* means a knee that is not *anatomically abnormal* or a knee that has not been subject of *specific trauma*, as defined below.
- *Anatomically abnormal knee* means a knee that is affected by underlying muscle weakness or imbalances, neurologic abnormalities, or anatomic variations (such as valgus or varus deformity of the knee, or a mild joint dysplasia).
- *Specific trauma* means significant physical injury to a joint, including a fracture involving the intra-articular surface of the joint, surgery, and penetrating injuries from projectiles.
- *Obesity* may cause or aggravate unilateral or bilateral OA of the knee.
Obesity means a significant increase in body weight by way of fat accumulation (of the order of a 20% increase in baseline weight), with a body mass index (BMI) of 30 or greater, which have been present for at least 10 continuous years.

$$\text{BMI} = \frac{\text{weight in kgs}}{\text{height in metres squared}}$$
This definition excludes weight gain resulting from edema, peritoneal or pleural effusion, or muscle hypertrophy.

CAUSATION:

1. Cumulative joint trauma associated with occupations in an individual with a normal knee
For cumulative joint trauma associated with occupations to cause OA in a normal knee in a non-obese individual, the following criteria should be met:
Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 10 years; *and*
Signs/symptoms of OA should be present in the knee joint during this timeframe or within 25 years after the activity ceases.
2. Cumulative joint trauma associated with occupations in an obese individual **or** in an individual with an anatomically abnormal knee **or** in an individual with a knee that has previously sustained specific trauma

*For cumulative joint trauma associated with occupations to contribute to OA of the knee in an obese individual, **or** in an individual with an anatomically abnormal knee ,*

or in an individual with a knee that has previously sustained specific trauma, the following criteria should be met:

Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 5 years; *and*

Signs/symptoms of OA should be present in the knee joint during this timeframe or within 25 years after the activity ceases.

3. Cumulative joint trauma associated with sports and/or exercise activities in a non-obese individual with a normal knee

For cumulative joint trauma associated with sports and/or exercise activities to cause OA in a normal knee in a non-obese individual, the following criteria should be met:

Cumulative joint trauma associated with sports and/or exercise activities should take place for a total of at least 5 hours per week for a period of at least 10 years; *and*

Signs/symptoms of OA should be present in the knee joint during this timeframe or within 25 years after the activity ceases.

4. Cumulative joint trauma associated with sports and/or exercise activities in an obese individual *or* in an individual with an anatomically abnormal knee *or* in an individual with a knee that has previously sustained specific trauma

*For cumulative joint trauma associated with occupations to contribute to OA of the knee in an obese individual, *or* in an individual with an anatomically abnormal knee, *or* in an individual with a knee that has previously sustained specific trauma*, the following criteria should be met:

Cumulative joint trauma associated with sports and/or exercise activities should take place for a total of at least 5 hours per week for a period of at least 5 years; *and*

Signs/symptoms of OA should be present in the knee joint during this timeframe or within 25 years after the activity ceases.

AGGRAVATION:

1. Cumulative joint trauma associated with occupations in a non-obese individual in the aggravation of pre-existing knee OA

For cumulative joint trauma associated with occupations in a non-obese individual to aggravate knee OA, the following criteria should be met:

Increased signs/symptoms of OA develop during the activity, or within 30 days of stopping the activity; *and*

Increased signs/symptoms of OA last for a period of at least 6 months, on a continuous or recurrent basis, whether or not the activity has stopped.

2. Cumulative joint trauma associated with sports and/or exercise activities in a non-obese individual in the aggravation of pre-existing knee OA

For cumulative joint trauma associated with sports and/or exercise activities in a non-obese individual to aggravate knee OA, the following criteria should be met:

Increased signs/symptoms of OA develop during the activity, or within 30 days of stopping the activity; *and*

Increased signs/symptoms of OA last for a period of at least 6 months, on a continuous or recurrent basis, whether or not the activity has stopped.

3. Obesity may be a factor in aggravation of unilateral or bilateral knee OA when the criteria set out in the Definitions subsection are met.

Exclusions:

The following activities are not considered activities which would cause OA in a normal knee joint, or aggravate knee OA:

- running that is not of high intensity or high mileage
- stairclimbing*
- walking on uneven ground*

*The level and intensity of the noted activities are what is anticipated to occur on an informal basis in daily life.

ANKLES:

Definitions:

- *Cumulative joint trauma associated with occupations* means kneeling or squatting in combination with carrying of loads of at least 35 kg on most days, **or** lifting of 35 kg loads in a twisted or bent position.
- *Normal ankle* means an ankle that is not *anatomically abnormal* or an ankle that has not been subject of *specific trauma*, as defined below.
- *Anatomically abnormal ankle* means an ankle affected by underlying muscle weakness or imbalances, neurologic abnormalities, or anatomic variations (such as valgus or varus deformity of the ankle, or a mild joint dysplasia).
- *Specific trauma* means significant physical injury to a joint, including a fracture involving the intra-articular surface of the joint, surgery, and penetrating injuries

from projectiles.

CAUSATION:

1. Cumulative joint trauma associated with occupations in an individual with a normal ankle

For cumulative joint trauma associated with occupations to cause OA in a normal ankle, the following criteria should be met:

Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 10 years; *and*

Signs/symptoms of OA should be present in the ankle joint during this timeframe or within 25 years after the activity ceases.

2. Cumulative joint trauma associated with occupations in an individual with an anatomically abnormal ankle **or** in an individual with an ankle that has previously sustained specific trauma

*For cumulative joint trauma associated with occupations to contribute to OA of the ankle in an individual with an anatomically abnormal ankle **or** in an individual with an ankle that has previously sustained specific trauma, the following criteria should be met:*

Cumulative joint trauma associated with occupations should take place for at least 2 hours per day, on at least 51% of days worked, for a period of at least 5 years; *and*

Signs/symptoms of OA should be present in the ankle joint during this timeframe or within 25 years after the activity ceases.

AGGRAVATION:

1. Cumulative joint trauma associated with occupations in the aggravation of pre-existing ankle OA

For cumulative joint trauma associated with occupations to aggravate ankle OA, the following criteria should be met:

Increased signs/symptoms of OA develop during the activity, or within 30 days of stopping the activity; *and*

Increased signs/symptoms of OA last for a period of at least 6 months, on a continuous or recurrent basis, whether or not the activity has stopped.

Exclusions:

Obesity is not considered a risk factor in ankle OA.

The following activities are not considered activities which would cause OA in a normal ankle joint, or aggravate ankle OA:

- running that is not of high intensity or high mileage
- stairclimbing*
- walking on uneven ground*

*The level and intensity of the noted activities are what is anticipated to occur on an informal basis in daily life.

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