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Review article

Occupation related gait alteration: A systematic review

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ABSTRACT

Kinematics describes the way the body moves. The human anatomy is an extremely complex and comprehensive description of how all body parts move. The systemic study of human motion during walking is referred to as gait analysis and the related advanced analysis methods have been in practice in the medical field in current years. People while working maintains the same posture for a long time like workers in the field of construction, carrying heavy load, automotive, agriculture and army are highly exposed to fatigue and work-related injuries. In this review article, the occupational hazard as a threat to the kinematic alteration of the lower limb is reconsidered and can be approached for prevention and further research on occupational related gait changes. A wide variety number of studies have reported categorization prototypes of gait but the literature survey addressing exclusively the changes in the data with regard to gait categorization is very inadequate. To aim at the same a vivid electronic search was also done on Pubmed, Scopus, Embase, Physiotherapy evidence database, Cochrane library, and Web of Science databases. Research Questions and methodology arrived with the search. After the full-text screening of the literature 20 studies were selected for critical evaluation. The idea of the same enabled us to propose to evaluate and appraise the alterations in the gait of workers and would be helpful in the future to further research on the occupational impact.

Keywords: Gait analysis, Occupational Gait Alteration, Kinematic Gait changes, Functional Gait Adaptation, Working postures.

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INTRODUCTION

Gait analysis is the process of determining what is causing a person to walk the way he does. Human locomotion or gait is described as a translatory progression of coordinated rotatory movements of the body segments. Knowledge of kinematics is essential for analysing, identifying, and correcting the abnormalities in gait. Analysis of gait is based on the measurements done using instruments and also on biomechanical interpretation [1]. Abnormal kinematics is an important factor in gait changes and physical disability. People who maintain the same posture for a long time are at risk of being exposed to fatigue and work-related injuries.

Gait analysis is essential to identify the structural, biomechanical, and functional limitations of the body. It helps to develop the treatment strategy and measure the outcome of treatments [2, 3]. Human walking is flexible on short and long timescales. On account of external perturbations, alteration in gait pattern and the corresponding change in motion system can be witnessed [4]. A change in any parameters of biomechanical gait stability may be a risk factor associated with extrinsic falls of workers. Maintaining balance and coordination of the entire body can be defined as stability during gait. And the same can be assessed by biomechanical gait stability parameters, the vital safety gait metrics [5,6].

The report by NIOSH (National Institute for Occupational Safety and Health) after an epidemiological study brings out the association between physical effort and its related musculoskeletal disorders at work [7]. Certain human gestures such as monotonous recurring motion, extreme application of force, uncomfortable or constant postures, extended sitting, and standing may be the causative factors for musculoskeletal disorders [8]. Biswas et al. found that people who sit for 8 or 9 hours a day fall in the risk factor group for occupational hazard especially, in people who do not exercise regularly [9]. Sedentary behaviour also has a negative impact on physical health [10]. Awareness of gait patterns is important for workers in occupational health and safety services. Many studies have addressed the classification of gait patterns in general, but literature pertaining to classification with respect to occupational alterations of gait is sparse.

In recent year's publications focus on one of the broad areas of interest which is an alteration in the gait pattern of individuals. This review summarizes the occupational impact as a risk factor for kinematic alteration of the lower limb in workers, which can be used to derive recommendations for prevention and any further research on functional adaptational gait changes.

An electronic literature search was carried out on Pubmed, Scopus, Embase, Physiotherapy evidence database, Cochrane library, and Net of science databases. Epidemiological studies on occupational risk factors for changes of gait were identified for relevant studies through database and bibliography searches. We also searched distinctive reliable online articles such as thesis and book chapters for potentially eligible studies. All the resulting articles were reviewed and discussed by all the authors to further confirm their suitability for this review (**Figure 1**). From a clinical point of view, knowledge of normal walking among healthy people is of primary importance. The study about a person's walks or runs reveals the unique pattern of movement of individuals, prognostic and diagnostic modalities related to cure and treatment of abnormal gait patterns. An abnormal or asymmetrical gait pattern without any symptoms is common in most people. But when the normal gait is altered after an injury or pain may result in greater health issues.

Figure 1: PRISMA flow diagram of the article search and screening for data extraction

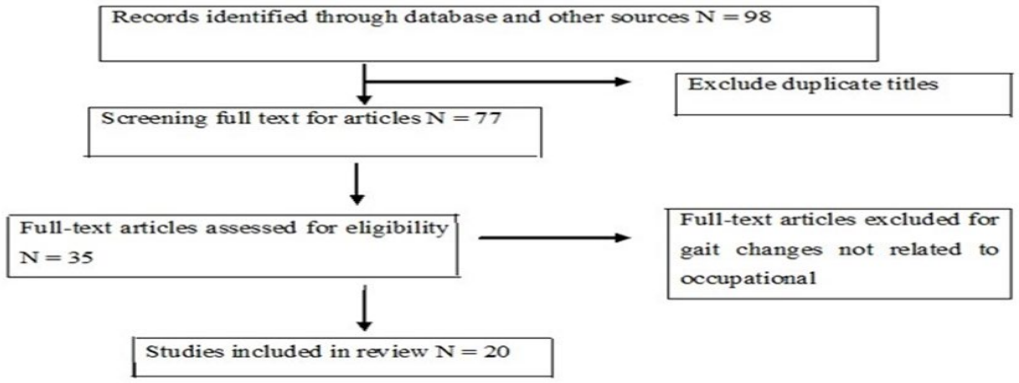

Table 1: Occupational impact on gait alterations – related studies characteristics and methodological approaches included in the review

Authors & Year of study	Number of subjects	Age groups	Types of workers	Outcome parameters	Results
Guha Thakurta A, Iqbal R, De A, 2017[18]	20	21-40	Construction worker	Visual 3D to reassemble reflective markers was used.	Methods of carrying load affected all the gait parameters and they found significantly different gait patterns such as stride length, cadence, cycle time, stride width, double limb support, and walking speed.
S.J. Marr and S. Quine, 1993[32]	321	18-64	Multiple industrial workers	Podiatrist & pedograph	The high percentage of subjects reported foot problems and existing foot conditions were affected adversely.
Woo et al, 2002[16]	10	25.7 ±1.883	Load-carrying tasks	Mikromak Co was used to analyze gait parameters.	Carrying load showed significant variants on kinematic gait parameters such as stride length, cadence, cycle time, and walking speed.
Neila Mezghani et al, 2015[19]	78	18 years & above	Knee straining workers (KS)	Three-dimensional (3D) knee kinematics signals concerning the frontal, sagittal, and transverse planes were recorded.	According to Bayes decision rule, 83.3% are more similar to the osteoarthritis group gait pattern.
Elke Ochsmann et al, 2016[26]	20	33.2 ± 10.5	Automotive workers	CUELA system (Computer-aided recording and long-term analysis of the musculoskeletal system)	Kinematic alterations of gait such as trunk inclination, hip angle, and knee range of motion as well as anticipated differences in plantar pressure distribution were observed due to wearing different safety shoes.
Nguyen et al, 2015[28]	40	18 years & above	Farmworker	Portable computerized walkway (GAITRite; CIR Systems, Havertown, PA).	The velocity of gait, cadence, and variability in stride & step length of farmworkers are significantly varied.
C. S Chulze et al, 2014[25]	32	20 -53	soldiers	Treadmill-Two-dimensional (2D) video-based motion analyses and Goniometric measurements.	Stride length was increased significantly in 2 - 4 cm and also the hip joint range of motion was affected.
D. Majumdar et al, 2010[31]	10	23.3 ± 2.6	Soldiers	Six camera-based 3-D HiRes Expert Vision Systems of M/s (Motion Analysis Corporation, Santa Rosa, CA, USA) and 25 Cleveland Clinic retro-reflective surface markers were used for full-body dynamic trials.	Increased stride length and cadence were observed due to carrying the load.

The assessment of the same gait disorder or gait abnormalities on a clinical approach is referred to as clinical gait analysis. For some of the physical problems such as back pain, muscle strain, and joint pain in the lower limbs may be due to abnormal gait [11]. The major reasons for alteration in gait pattern may be due to any injury, fracture, stroke, neurological disorder, or biomechanical problems [12]. With this small note, the analysis of gait shows a major impact on health diagnosis and observes the variation of gait performances.

Walking or gait involves the maintenance of balance,

control of the movement of the trunk, upper and lower limb in coordination, and also acts in response to changes in the external environment [1]. At every age, gait has its significance on wellbeing of a person, and also it changes due to various factors like age, anatomical, physiological, pathological, environmental, cultural, and occupational. This review illustrates the occupational impact on gait changes of workers in multiple worksites. There will be gait differences between a manual worker and an office worker as well as between someone active and someone sedentary. Workers on standing throughout the day in their work lead to progressive fatigue and strain on legs and feet for prolonged standing will impact on gait. [13]. In the workplace, there is less involvement of physical movement

Overview of various approaches towards the occupational impact on gait alterations

Construction workers

The construction workers have the risk of musculoskeletal injuries higher than other industrial workers due to repeated changes in postures like bending forward, standing, and weight-bearing [14]. The construction workers are at significantly higher risk of falls with the evidence of their physiological features such as postural balance and gait stability [15]. Woo et al reported that gait patterns significantly differ in subjects who carry weight [16]. Gait instability with the change in their body's centre of gravity due to uneven carrying of load one-sided, threatening fatigue seems to be an external factor for higher fall risk among workers. Walking at high speed may show a negative impact on workers' gait patterns [17]. Methods of carried load may influence all the gait parameters such as stride length, cadence, cycle time, stride width, double limb support, and walking speed [18]. Study on construction workers gait patterns may reveal the fact about the different types of imbalance and thereby forms a strategy for the prevention of fall.

Knee straining workers

Neila Mezghani et al reported that the similarities of the kinematics of Knee straining workers and osteoarthritis (OA) patients. This further justifies that knee-straining workers have a gait pattern which may pose a risk of developing the disease soon [19]. Knee-straining workers during the stance phase of the gait cycle have knee adduction and a greater foot contact angle. This adducted position of workers of the marks overload on the knee on the medial compartment and coherent to OA knee [20]. The awareness stating the likeliness of OA patient gait pattern with the knee straining workers may bring out further prospective studies and also the prevention of it before the onset of the disease [19].

Automotive workers

Surprisingly, Gait can be affected by the footwear as it may influence the joint movements, and forces due to plantar pressures [21-24].

leads to a higher risk of work-related disorders. Appropriate intervention measures can reduce the incidence and severity of occupational-related musculoskeletal problems.

Description of included studies

Table 1 includes the description of the included papers. Only a limited number i.e. eight studies evaluated an occupational impact on gait alterations out of 20 selected studies. In these eight studies, 531 participants' age of the individuals ranged from 18 to 78.7 years. All eight included studies examined gait changes due to occupational impact. Out of these six studies evaluated biomechanical parameter changes of gait and one study examined the pattern of gait while another study evaluated foot condition and plantar pressures during walking.

Development of musculoskeletal complaints increases when prolonged walking and standing on hard surfaces in working place. Safety shoes may play an imperative part within the interface between the flooring and musculoskeletal system. Limitations of the ankle joint movement are influenced by the material and shape of the shoes [25]. The preference of safety shoes plays an important impact to meet between the flooring and the musculoskeletal system, it may also prevent negative health effects on the musculoskeletal system in workers, particularly when prolonged standing and walking on hard surfaces is required in a working environment [26]. Johnson reported that the workers prolonged standing with the constant wearing of imperfect shoes on hard floors of working places are the main cause of foot problems [27]. Workers wear safety shoes to protect against occupational injuries during working hours every day. For workers, it is important to have the knowledge that unstable footwear will alter gait stability in daily life activities.

Farmworkers

The farmworkers fall in risk factors related to occupational hazard injuries related to gait. Nguyen et al conducted a study on farmworkers and have reported no significant differences in stride length, step length, and double support time; but they found variability in stride length and step length. They suggested in their findings that farmworkers walked at a slower speed but with a more prominent step-to-step variability that indicates a compensatory response to gait instability and the farmworkers are thus associated with poor gait function [28]. The attention of the occupational effect on gait alteration will help become aware workers of the risk for falls and likely appropriate preventive interventions.

Soldiers

Carrying equipment is a vital part of the daily process for infantry soldiers. Footwear and equipment of soldiers have a significant influence on biomechanical parameters of gait analysis [25]. Kinoshita studied biomechanical alterations while carrying loads of varying magnitudes in the support phase of gait and reported that the

subjects desired to walk at a slower speed using a shorter stride length whereas carrying overwhelming loads [29]. Carrying lighter load also produced quantifiable and critical adjustments in spatiotemporal parameters [30]. Soldiers carrying equipment on various parts of the body like on the back, waist, hand, and shoulder of varying shapes and size, leads to uneven distribution of weight and this may lead to an alteration in gait parameters [31]. Carrying heavy loads or repetitive low loads plays a vital element within the development of musculoskeletal disorders.

CONCLUSION

This review proposes suggestions for inconsistent approach in future studies on gait evaluation in healthy workers and importance of occupational impact on gait alterations. It is not possible to estimate accurately an occupational gait change from existing records, but enough facts is existing to recognize job-related hazards which will prove helpful for a better understanding and to manage gait adaptation. Further, the students, researchers, and investigators of different disciplines can integrate the understanding of gait into their field and learn more. Thus, we should sensitize the workers across multiple worksites about the effect of alterations of gait in the workplace and the risk associated with various occupations. In light of this review, future research should identify specific risk factors for work-related adaptations of gait as well as the necessity of providing quantitative exposure measures to enforce these adaptations.

DECLARATION

Conflict of interest

None.

Ethical approval

Not required.

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