International Journal of Occupational Safety and Ergonomics (*JOSE*) 2010, Vol. 16, No. 4, 507–523

REVIEW

Functional Limitations and Occupational Issues in Obesity: A Review

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Four hundred million adults are obese. Such a pandemic involves people of working age. Excess weight imposes abnormal mechanics on body movements, which could account for the high incidence of musculoskeletal disorders in these subjects. This article reviews the physiological and biomechanical causes of the reduced work capacity in obese workers and speculates on the relationships between occupational exposure and obesity. The reduction in work capacity appears to be due to the following factors: reduced spine flexibility, decay in endurance, limited range of movement of the major joints, reduced muscle strength and capacity to hold prolonged fixed postures, impaired respiratory capacity and visual control. Work capacity in morbidly obese workers should always be evaluated to match specific job demands. Due to the relationship between obesity, musculoskeletal disorders, disability and health costs, prevention of obesity and ergonomic interventions on-site are a priority in the work place.

physical work capacity   obesity   functional limitations   musculoskeletal disorders

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The authors wish to thank H. Precilios and E. Tacchini for their assistance in the bibliographic search.

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1. INTRODUCTION

Obesity is a clinical condition that is characterized by excessive body weight in relation to the individual's height. Different grades of obesity have been identified by the World Health Organization (WHO) according to the body mass index (BMI) expressed in kilograms per square meter. Being overweight is defined by a BMI of 25–30, grade 1 for a BMI > 30, grade 2 for a 35 < BMI < 40, and grade 3 for a BMI > 40. The prevalence of obesity has increased over the last century [1], substantially in the last few decades [2].

The 2006 WHO report reveals that over 1 000 million individuals worldwide are overweight and at least 400 million adults are obese [3]. In Europe, 5–20% of men and 8–30% of women are obese [3]. In Italy, the prevalence of obesity has increased from 8.5% in 2002 to 9.8% in 2006 with 42.5% of men and 26.6% of women overweight [4]. In the USA, 6.9% of women and 2.8% of men are morbidly obese (BMI > 40) [5].

The percentages increase with age: between 18 and 24 years of age, 2.1% are obese and 13.1% overweight; between 65 and 74, 15.6% are obese and 46.1% overweight [3]. The pandemic involves people of working age: in the USA one out of every three workers is obese [6, 7]. The economic consequences of an increased percentage of obese workers are relevant in terms of health costs and absences from work [8]. Indeed, obesity is associated with reduced participation in the workforce [9], increased absence from work, disability and health costs [10], lower salaries [11] and reduced productivity [12]. It also causes a 13-fold greater loss of working days and an 11-fold higher number of compensation claims [8, 13]. Obese workers are more often on sick leave for over 8 days at a time [14]. Employers' direct and indirect costs increase in parallel to the workers' BMI [15]. In morbid obesity (BMI > 40), healthcare costs are 69–81% higher than in normal-weight workers [16, 17, 18], with an annual per capita cost for the loss of working days of 460–2 485 USD [8]. Considering the prevalence of obesity in the workforce in the USA, the estimated loss for a north American factory with 1 000 employees would be ~285 000 USD per year [19]. Obesity also represents a major risk factor for premature job leave [20, 21].

2. OBESITY AND HEALTH STATUS

Several epidemiological studies have shown an association between BMI and chronic conditions such as hypertension (odds ratio, OR: 2.9 in men and 3.3 in women), ischaemic heart and cerebral conditions (OR: 1.3 in men and 1.1 in women), several types of cancer (bowel, endometrial, breast, prostate) (OR: 1.0 in both genders), diabetes mellitus type 2 (OR: 3.1 in men and 3.8 in women), osteoporosis (OR: 1.9 in men and 0.9 in women), arthropathies (OR: 1.5 in men and 1.7 in women) and depression (OR: 1.3 in men and 1.2 in women) [22]. Twenty to 60% of morbidly obese subjects show a fivefold higher incidence of psychiatric disorders such as anxiety or depression as compared to their lean counterparts [23]. The association between obesity and mortality risk is not univocally clear. In fact, some studies report an increased mortality risk in parallel to BMI increases [24, 25], whereas a recent review shows that the risk is higher in individuals with a BMI < 20 rather than in those with a BMI > 35 [26].

3. FUNCTIONAL LIMITATIONS IN OBESITY

Our knowledge of the multifactorial pathogenetic causes of obesity has grown over the last decades but it is only quite recently that the functional impact of the condition has started to be unveiled [27, 28]. The reduced physical capacities under investigation range from basic activities such as rising from a chair, lifting an object, and walking or carrying bags [28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39], to occupational tasks [28, 33, 40, 41, 42, 43].

Excess weight imposes abnormal mechanics on body movements [27, 44], which could account for the high incidence of musculoskeletal disorders in these subjects. Pain and osteoarthritis, both known determinants of disability [1, 45], are often correlates of obesity, in particular at knee, hip and spine level [46, 47]. Body shape is influenced by the excess of mass [48, 49, 50], which can hinder the joints' physiological range of motion and enhance the risk of musculoskeletal overload [27].

The spine shows a limited flexibility and increased dorsal stiffness [51, 52], obviously affecting the execution of job tasks involving the trunk. In the lower limbs, greater mechanical loads have been measured at knee level. Together with the observed decrease in knee extensor and flexor muscle strength, this explains the high incidence of early knee osteoarthritis in obese subjects [35].

The decay in endurance, range of movement of the spine and major joints, muscle strength, capacity to hold prolonged fixed postures, respiratory capacity, visual control have a combined negative effect on both work capacity and quality of life [44].

3.1. Posture

Excessive body weight affects posture linearly with the increase of BMI [52, 53], akin to what occurs in the later stages of pregnancy [54]: the centre of gravity shifts forward, the lumbar lordosis increases together with the pelvic forward tilt, the dorsal kyphosis and a secondary cervical lordosis become more pronounced [48, 53, 55]. Frequently, internal rotation of the hips, knee valgism and flat feet coexist. The feet tend to splay apart during standing to optimise the centre of gravity and stability. This occurs also in the seated posture to facilitate trunk flexion and to reduce weight on the pelvis [54].

Discomfort and reduced tolerance of fixed postures are also consequences of a redundant mass. Pain has been shown to affect posture [48]. Reduced sensory integration has been hypothesised for the poor balance [53, 55, 56]. Reduced balance affects a variety of daily and occupational tasks, particularly those performed with the upper limbs from a standing posture [57]. Obesity would therefore appear to be linked to an increased risk of falling [48, 58], while weight loss increases postural stability [55]. However, whether this is due to weight loss per se or to the beneficial effects of physical activity needs further investigation [27]. Not only does BMI increase but also its fluctuations (e.g., in eating disorders) show a correlation with reduced stability [51, 59]. High BMI values are coupled with increased bone density and a protective layer of fat around the joints. But still obese subjects are not protected against falls [55], and older obese subjects in particular are at a high risk of falls and fractures [60, 61].

3.2. Muscle Strength

Changes in body mass and composition affect muscle strength: compared to their lean counterparts, obese subjects show both higher absolute fat and lean mass values [27, 62]. However, when normalized to body weight, strength appears 6–10% lower in obese subjects: despite greater muscle mass, they are significantly weaker than normal-weight subjects [62]. Reduced muscle strength could possibly stem from diminished muscle function, abnormal metabolism (lower oxidative capacity of muscle fibres, despite their hypertrophy), and lower physical activity levels, also shown by reduced motor unit activation during exercise [63].

Due to mechanical limitations, absolute muscle power is the same as normal-weight subjects and gender differences remain the same [64]. Thus, obese workers are less efficient and this should be taken into account in job tasks demanding prolonged physical effort. As for the lower limbs, the knee flexor and extensor ratio is lower in obese subjects, presumably because of a training effect of the antigravitary muscles exposed to greater loading [62]. Muscle efficiency of the lower limbs is known to be a key factor for a wide range of activities ranging from basic mobility to a variety of job tasks. A strong correlation between flexor and extensor strength and capacity to perform daily activities safely has been shown [65]. Obesity associated with reduced muscle strength (sarcopenic obesity) increases the risk of disability [66]. Inadequate muscle strength in a heavy body also means early fatigue. In the quadriceps femoris, this phenomenon can reduce shock absorption

[67], increase mechanical loading at the knee during walking [56, 68] and enhance the risk of developing early osteoarthritis [69, 70].

3.3. Cardiorespiratory Capacity

Obesity is correlated with reduced levels of physical activity as compared to normal weight [71]. The excess of body mass affects the energy expenditure of movement and the cardiovascular response: obese subjects show a lower oxygen consumption in relation to body mass and perform early anaerobic work during exercise [72, 73, 74]. The dynamics of breathing may be affected due to pressure on the diaphragm resulting in reduced pulmonary compliance. Grade 1 obesity implies a reduction in pulmonary volumes and changes in respiratory mechanics in the supine and seated posture as well as during exercise [75]. Obese subjects with severe obstructive sleep-apnea show amplified haemodynamic responses to exercise [76]. Furthermore, obesity is characterized by an increase in circulating blood volume with hypertrophy of the left ventricle affecting its volume and diastolic compliance. Due to the aforedescribed cardiovascular system, obese workers do not seem capable of meeting metabolic demands, particularly for sustained work loads [73, 74, 77]. Work tasks involving climbing/descending stairs, squatting, reaching objects yield noticeable energy expenditure levels that should be carefully evaluated to match the obese worker's capacities. Generally, 30-min work tasks at 30% of the aerobic capacity with adequate recovery phases represent a mild intensity job that can be sustained by most workers.

3.4. Walking

Walking alone can be a potential source of mechanical overloading. In fact, obese subjects show a higher rate of degenerative joint conditions of the lower limbs [37]. Higher metabolic expenditure and reduced gait efficiency [78], probably due to the inertia of the abnormal mass in the limbs [79], are features of obesity. Weight loss improves gait efficacy by reducing metabolic expenditure [27].

Self-selected gait speed is slower in obese subjects as compared to their lean counterparts and their motor pattern is characterized by a reduction in step length and frequency, shorter swing and longer single and double stance phase. Such spatiotemporal changes have been interpreted as attempts to maintain dynamic balance [27, 38]. Obese subjects basically adapt their gait so as to reduce the load at knee level and the metabolic expenditure of gait [80, 81, 82]. In the sagittal plane, they show greater trunk extension, reduced hip and knee flexion, increased plantar flexion, and external rotation of the feet [38]. Ankle torque is much higher in the obese as compared to subjects of normal weight. All these changes have been interpreted as neuromuscular reorganization aimed at reducing knee loading [83]. During stance, despite larger contact area, dynamic pressure on the heel, medial foot and metatarsus is higher [27]. Female obese subjects show a significantly reduced hip and knee range of motion, due to the peculiar gynoid mass distribution in the lower body [84].

3.5. Motor Tasks

The speed of movements is generally lower in obese subjects, especially in antigravitary actions [33]. Rising from a chair can be performed on average 90 times a day by an adult person. Its motor pattern is a combination of centre of mass control, trunk positioning, feet placement, neuromuscular co-ordination and muscle strength. Obese subjects adopt a different strategy from their lean counterparts: less trunk flexion and more pronounced backward positioning of the feet. This helps to reduce hip load, but unfortunately increases knee load twofold [35]. Job tasks involving prolonged kneeling result in an increased risk of knee osteoarthritis, especially when BMI exceeds 30 (OR 14.7) [40].

In the general population, the speed of hand movements slows down linearly with the decrease in the target dimension. In obese subjects this decay is significantly greater [57]. Both the accuracy of fine movements [57] and elbow range of movement [85], crucial for precise hand positioning, have been shown to lessen. Therefore, obese workers may be less precise and efficient in job tasks that call for precise upper limb movements whilst standing. BMI, together with forearm and hand length, accounts for more than 85% of the variance of grip strength [86]. Based on biomechanical data of the elbow [57, 85], hand–wrist [87] and dorsal spine [51], an overload of the glenohumeral joint during job tasks can be hypothesised. In fact, the rate of musculoskeletal disorders in the shoulder region is higher in obese subjects [88, 89] and one possible explanation could be that this joint acts to compensate postural changes in the spine (dorsal stiffness) and upper limb (reduced range of motion at elbow and wrist).

The hips and lumbar spine show a reduced range of motion and are frequently affected by early degenerative phenomena [35, 38, 51].

Reduced dorsolumbar flexibility induces postural changes during prolonged work while standing, with an increased mechanical load on the hip. This is particularly evident in obese females [53]. BMI affects trunk kinematics during lifting, resulting in higher loads on the transverse and the sagittal plane [28]. During forward flexion of the trunk, the lumbar trait of the spine undergoes the highest torques and is therefore a major target of degenerative conditions [51]. Recommended weight limits, as measured with psychophysical methods, have been set for normal-weight workers and also dimensional parameters (horizontal and vertical distance) should be reconsidered for overweight.

3.6. Disability

Studies using quality of life questionnaires reveal the negative impact of the increase in BMI [90]. The relationship between BMI and disability in daily life activities, independently from the presence of chronic conditions, has emerged in recent studies [91]. Obese subjects have a significantly lower number of disability-free years (5.7 for men and 5.0 for women) [49]. Consequently, the demand for rehabilitation and social interventions together with medical treatment is greater [92]. As Rejeski pointed out, the likelihood of experiencing functional decline is greater as BMI increases [93].

The literature suggests a hierarchy in the onset and development of disability related to obesity: the first functions to be affected are those related to the lower limbs (strength and balance), then those related to the upper limbs (strength and dexterity) [8]. Obesity is also associated with loss of lean mass (sarcopenia) [94] and these two elements act synergically in the development of disability [95].

4. WORK-RELATED MUSCULOSKELETAL DISORDERS (WMSD)

In addition to the known risk factors (age, female gender, repetitive work, demanding exertions, localized pressure, posture, environmental temperature, exposure to vibration, job design) [96, 97], obesity per se represents a risk factor for the onset of WMSD. The most frequently involved body districts are spine, and upper (wrists, forearms, shoulders) and lower limbs (hips, knees, ankles). The interaction of chronic conditions, fatigue, drowsiness and reduced physical capacity has been hypothesised to cause WMSD [98, 99].

Obese workers have a twofold higher probability of developing upper limb tendinopathies [100, 101, 102, 103, 104] and a fourfold higher probability of developing carpal tunnel syndrome as compared to those of normal weight [105, 106, 107]. Progressive slowing of the median nerve conduction velocity at the wrist could be secondary to the biomechanical stress posed by the fat tissue within the carpal tunnel [27]. Other genetic factors could play a concurrent role [108].

Recent studies analyse the role of the metabolic factor adipocytokine in influencing the musculoskeletal system and the associated degenerative and inflammatory conditions (osteoarthritis, reumathoid arthritis, spondilo-arthropathy, fibromyalgia) [109].

Occupational back pain is mainly related to overload on the spine during manual handling [97]. However, obesity itself could represent a persistent cause of overload on the spine and related nervous, discal and ligamentous structures [49]. An association between weight in excess, smoking habits, level of physical activity, high C-reactive protein and back pain has been described [110].

At odds with what occurs in normal-weight subjects, rest does not seem to compensate the body height reduction secondary to the compression/dehydration of the intervertebral disks during the working day [49]. Despite biomechanical models providing insights into the increased compression and shear forces on the spine during lifting, there is no clear epidemiological evidence of a strong correlation between BMI and back pain [111]. BMI is probably not an ideal indicator for functional capacity, since higher BMI can be associated with subjects with a high percentage of fat mass or a high lean mass [90]. Also, BMI may be unsuited in specific populations (e.g., Inuit, Asiatic), when the length of the lower limbs and height from a seated posture provide more information than the total body height used to compute BMI.

As for traumatic work injuries, few studies reported that the risk was higher in relation to obesity and only one study clearly demonstrated that weight reduction could prevent injuries [112]. Possible mechanisms involved in trauma events are gait disturbances and physical limitations; fatigue due to sleep apnea; poor ergonomic fit; and regular use of medication to treat disease associated to obesity. In general, the ability of the body to tolerate hazardous energy exposure or relevant stress situation is reduced [99].

It has been reported that obese employees experience a two- to threefold risk of work disability compared to their normal weight subjects [113]. Recently, also in a large group of construction workers an association between BMI and all-cause work disability was found. Cause-specific analysis showed that musculoskeletal disorders (46.2%), especially back problems, were the most frequent followed by cardiovascular diseases (17.1%), mental disorders (8.9%) and cancer (8.1% particularly of the lungs) [114].

The risk of obesity-related injuries and injuries linked to specific jobs is another aspect that has been poorly investigated. A research on firefighters reported that a 1-unit increase in BMI was associated with a 5% increase in work disability [70, 90].

5. OCCUPATIONAL EXPOSURE AND OBESITY

The complex relationship between occupational exposure and obesity cannot be simplified into a causative link among obesity and morbidity, mortality and WMSD [99]. Obesity can aggravate the onset of a condition (e.g., working in a kneeling posture favours the onset of knee osteoarthritis, which is aggravated by obesity), but also occupational risks and obesity act as independent factors to cause a disease (e.g., repetitive upper limb activities and obesity cause carpal tunnel syndrome; work strain and obesity cause cardiovascular diseases). There are occupational factors which favour obesity (e.g., shifts, strain at work), but also work can cause a condition which interacts with obesity or an obesity-related condition (e.g., exposure to vibration and diabetes).

Compared to the odd occupational risks (manual material handling, use of vibrating tools, adverse environmental conditions, physical strain, awkward posture, noise, duration of the work cycle), which are associated with a probability (OR) of WMSD between 1.8 and 5.2, obesity is associated with a 2.05 OR. The same risk level has been described in alcoholism [41, 115].

In particular the risk of WMSD is 15 and 48% higher for overweight and grade-3 obese subjects, respectively, compared to normal-weight subjects [85, 103]. Physical inactivity and disability increase the risk of WMSD [8, 65, 115, 116].

Whether the obesity-related risk of injury is linked to specific jobs has been poorly investigated. A study of obese truck drivers revealed a higher risk of death after crashes [20, 117]. Another study of firefighters reported that 1-unit BMI increases were associated with an increase of 5% in work disability [90, 118].

Truck drivers show a higher incidence of obesity, physical inactivity, poor diet and smoking habits. In this population, brief sleeps are significantly related to obesity, high cholesterol and glucose levels, hypertension and sleep apnea [116, 119].

Shift workers generally show a higher BMI [6, 120]. Shift work appears to be an independent risk factor for weight in excess and obesity, and for alterations in lipid metabolism and insulin secretion.

Obesity is a risk factor for mortality due to exposure to high temperatures [121, 122].

The risk of endometrial cancer is particularly high in obese females working night shifts, which could be presumably attributed to the hormonal and metabolic effect of melatonine [59, 123]. Overweight builders have a lower risk of disability, while those with higher BMI show a higher incidence of osteoarthritis and cardiovascular disease [114, 122]. Obesity may also affect immunity and reactions to neurotoxic chemical substances [86, 124].

There is evidence that obesity increases the risk of asthma, WMSD (including vibration-induced ones) and shoulder problems [88, 89, 125].

The literature is presently lacking in threshold limit values for the obese working population. Obesity, like other disabilities, is supposed to follow different distribution functions compared to normal weight [126]. As for protected workers, there is a tendency to assume more restrictive normative values, e.g., to protect 99% of the obese population, with 0.1% exposed to the risk.

Threshold limit values for workers with WMSD have been identified [127]; however, such limits have not been validated in an obese work force.

For repetitive activities with the upper limbs, the following safety levels have been proposed:

- frequency lower than 20 per minute;
- use of minimal force, <5% of the maximal voluntary contraction (score 0.5 on Borg's CR-10 scale);
- absence of posture and tasks straining the major joints;
- adequate rest time during the work shift.

For manual material handling:

- 4–5 kg to be lifted 2–3 times with 30-min intervals (1 worker);
- 7–10 kg to be lifted few times with 30-min intervals (2 workers);
- 14–15 kg to be lifted few times with 60-min intervals (2 workers);
- >15 kg should be avoided.

6. PSYCHOLOGICAL ASPECTS

In addition to sedentary life-styles and high-calorie diets, psychological strain at work has been found to favour weight gain. Chronic stress at work increases twofold the risk of metabolic syndrome in men [128, 129]. However, this relationship and the underlying hormonal mechanisms have not been clearly demonstrated.

Male and female workers at the lowest hierarchical level were exposed to a twofold risk of developing metabolic syndrome [128, 129]. According to the Whitehall II Study, workers reporting a high level of injustice at work showed a tendency to be smokers, obese, sedentary and affected by hypertension [30, 130].

Obese persons are often stigmatized and have to cope with different forms of discrimination and prejudice [131, 132, 133, 134, 135, 136, 137, 138, 139]. However, attention to weight bias has undoubtedly increased, with a growing recognition of the pervasiveness of weight bias and stigma, and its potentially harmful consequences.

A recent meta-analysis of 32 studies [140] about weight discrimination in employment settings demonstrated that obese employees and applicants were given more negative evaluations and obtained more negative outcomes as compared to non-overweight persons in the same working conditions. Also, they faced significant disadvantages in positions requiring relationships with the public and coworkers' preferences [140].

Interestingly, even hospitals and medical settings are not immune to negative attitudes toward obese patients [131] and counseling and treating obese patients for weight reduction is perceived as unrewarding [141, 142, 143]. Such attitudes could well influence the quality of the care these health-care professionals are able to provide this category of patients. Moreover, they tend to devote inadequate time to overweight patients, despite scientific guidelines underlining the importance of providing information to improve the patients' lifestyles [144].

Weight-related stigma, particularly connected with body size rather than BMI, is indeed present in the obese population. A self-report questionnaire investigating 50 stigmatization experiences frequently associated with obesity (the stigma situations questionnaire) revealed that "comments from children", "negative assumptions by others" and "physical barriers" were among the negative perceptions experienced by 117 extremely obese individuals referred for bariatric surgery [145].

There is now strong evidence that obese employees perceive weight-based disparities at work and experience a wage penalty (controlling for sociodemographic variables); there is moderate evidence that they face disadvantaged employment outcomes due to weight bias. As for obese applicants, there is strong evidence that they face weight bias in job evaluations and hiring decisions [132].

7. ERGONOMIC ASPECTS

Obese subjects may encounter difficulties interacting with the surrounding space, furniture, tools, clothes, and tasks which are basically designed for normal-weight subjects [33]. These problems largely involve both daily and professional life; nonetheless, they have not been thoroughly and systemically explored and only a few ergonomic studies have addressed some of these issues in female workers in the later stages of pregnancy [146].

According to ergonomic accessibility criteria and the present conceptual frame for disability [147], the environment and its structures should be designed to match individual needs to maximize participation in activities and social roles.

Ergonomic interventions aimed at modifying workstations should consider accessibility and adherence to the criteria of independence, comfort, productivity and tolerability in the long term, minimizing the risk of overload which may eventually amplify existing functional limitations [127].

The workstation shapes the worker's posture. Design should take into account the main ergonomic principles (adaptability, ease of use, accessibility, adjustability) to avoid problems for both obese workers and their lean counterparts.

As for anthropometry, the most protruding point of the abdomen influences the subject's posture at the work desk, usually forcing the worker to be at a greater horizontal distance from the target with a more flexed trunk. In this way, the handling area within reach is limited, possibly hindering the accomplishment of the job tasks and increasing the risk of WMSD due to prolonged awkward postures.

The desk height of choice was lower than the standard height in a study conducted on female workers in late pregnancy [146]. The optimal height is also job-dependent: higher levels (5–10 cm over the elbow) are more suited to finer tasks, whereas lower levels (15–40 cm below the elbow) are for tasks requiring force. In the first case, there should be a free space under the desk to locate the abdominal mass. Thus, adjustable working surfaces are preferable. General ergonomic indications appear particularly valid for the obese worker: horizontal reaching distances within 50 cm, wrist movements within 20–30° of the physiologic range of motion, avoid wide grip greater than 6 cm or associated with vibrations, repetitive grips should not exceed 2 kg.

The poorer balance of the obese worker may increase the risk of falls and injuries during manual handling tasks performed in an upright posture. To prevent this, the workstation should be adequately sized, with safe and appropriate supports and nonslip surfaces. Repetitive fine motor tasks (use of keyboards, precision work) are influenced by the altered biomechanics of the upper limbs, typical of the obese. The position of the upper limbs is affected by the presence of abnormal abdominal mass, with increased ulnar deviation at the wrist and higher risk of WMSD. Modified keyboards, adjustable tools, minimal force requirements and handles with ergonomic grips have been developed to minimize these risks.

The use of tools and levers to minimize force requirement, goes some way towards lessening the compressive loads on joints and the spine, which are already high in the obese, and favours their tolerance of prolonged work. The slower movements of the obese whilst performing actions with the whole body (e.g., standing up, walking, sitting down) and fine motor tasks may suggest that amendments need to be made to the workload (shifts, frequent changes of posture, loads to be handled) to preserve the worker's safety and productivity goals.

There is a paucity of studies on issues of safety at work. Personal protective devices may be uncomfortable because of size, or even increase the risk of respiratory (e.g., filter masks) or thermoregulatory (e.g., protective garments) overload.

Obese subjects often avoid wearing seat belts whilst driving because of the discomfort and localized pressure [15, 127]. They are at higher risk of death when involved in car accidents compared to normal-weight subjects. The design of vehicles should take these data into consideration [48, 117]. Subjects with BMI > 32 frequently complain of daytime sleepiness, an obvious danger during driving [127, 148]

Safety norms should include regular check-ups and preventative measures for subjects at risk to maintain the health status and guarantee safety on the roads [127, 149].

The seated posture induces high compressive forces at spinal level which could have an impact on the ability to sustain the posture and favour the onset of WMSD. Comfortable sitting depends on the dimensional parameters of the work place fitted to the individual anthropometry (length of lower limbs, abdominal circumference, etc.) and on the provision of adequate feet and ischiatic support. Even pressure distribution at ischiatic level, along with support for the arms and back and possibly head and legs, contribute to achieving a balanced posture. The seat conformation (width and depth) would also depend on an android or gynoid fat distribution. Seat and backrest height and width, distance between the arm supports should be adjustable. Sit-to-stand is easier in the presence of adequate seat height and arm support. Inadequate seats on public transportation can discriminate obese subjects.

Narrow spiral staircases are dangerous due to poor visibility and inadequate support. High steps to access public transportation can hinder mobility and independence. Handrails should always be provided. The size, texture and ease of donnig and doffing of personal garments may represent other daily problems faced by obese subjects. Unfortunately, still very few brands deal with these specific aspects.

8. CONCLUSIVE REMARKS

Due to the relationship between BMI, disability, WMSD and health costs, prevention of obesity is nowadays a priority in many work places. Prevention and ergonomics in the work place may provide long-term benefits, especially if part of multidisciplinary interventions (reducing exposure to risk factors, weight-control programs, increasing levels of physical activity, environmental changes to support healthy life-style, mechanization of job phases) [104, 149, 150]. Such multilevel interventions have shown the greatest impact on positive changes lasting over time. They also reduce the need for a workers' compensation system [151]. Work capacity in morbidly obese workers should always be carefully evaluated to match specific job demands, particularly for relevant public jobs, shift work and manual handling.

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