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Rationale for hospital-based rehabilitation in obesity with comorbidities

P. CAPODAGLIO [1], C. LAFORTUNA [2], M. L. PETRONI [3], A. SALVADORI [4]
L. GONDONI [5], G. CASTELNUOVO [6, 7], A. BRUNANI [1]

[1]Istituto Auxologico Italiano IRCCS
Orthopedic Rehabilitation Unit and Research Laboratory
in Biomechanics and Rehabilitation
S. Giuseppe Hospital, Piancavallo, Verbania, Italy
[2]Istituto di Bioimmagini e Fisiologia Molecolare
National Council of Research, Milan, Italy
[3]Department of Biomedical Sciences
University of San Marino, Republic of San Marino
[4]Istituto Auxologico Italiano IRCCS
Pneumological Rehabilitation Unit
S. Giuseppe Hospital, Piancavallo, Pordenone, Italy
[5]Istituto Auxologico Italiano IRCCS
Cardiac Rehabilitation Unit
S. Giuseppe Hospital, Piancavallo, Pordenone, Italy
[6]Istituto Auxologico Italiano IRCCS
Psychology Research Laboratory
Ospedale S. Giuseppe, Piancavallo, Pordenone, Italy
[7]Department of Psychology
Catholic University of Milan, Milan, Italy

Severely obese patients affected by two or more chronic conditions which could mutually influence their outcome and disability can be defined as "complex" patients. The presence of multiple comorbidities often represents an obstacle for being admitted to clinical settings for the treatment of metabolic diseases. On the other hand, clinical Units with optimal standards for the treatment of pathological conditions in normal-weight patients are often structurally and technologically inadequate for the care of patients with extreme obesity. The aims of this review paper were to review the intrinsic (anthropometrics, body composition) and extrinsic (comorbidities) determinants of disability in obese patients and to provide an up-to-date definition of hospital-based multidisciplinary rehabilitation programs for severely obese patients with comorbidities. Rehabilitation of such patients require a here-and-now multidimensional, comprehensive approach, where the intensity of rehabilitative treatments depends on the disability level and severity of comorbidities and consists of the simultaneous provision of physiotherapy, diet and nutritional support, psychological counselling, adapted physical activity, specific nursing in hospitals with appropriate organizational and structural competences.

KEY WORDS: Obesity - Disability evaluation - Comorbidity - Rehabilitation.

Obesity with comorbidities leading to disability represents a real social and economic burden for the National Health Systems worldwide. The presence of multiple and associated comorbidities often represents an obstacle for being admitted to clinical settings for the treatment of metabolic diseases. On the other hand, clinical Units with optimal standards for the treatment of pathological conditions in normal-weight patients are often structurally and technologically inadequate for the care of patients with extreme obesity. The evaluation and treatment of patients with disabling obesity requires clinical facilities where these complex patients can be treated with appropriate therapeutic and rehabilitative protocols carried out by specially trained operators and within an environment, which is ergonomically adequate and safe for patients and staff alike.[1] Given the figures of obesity worldwide, it ap-

Corresponding author: P. Capodaglio, MD, Istituto Auxologico Italiano IRCCS, Orthopedic Rehabilitation Unit and Research Laboratory in Biomechanics and Rehabilitation, S. Giuseppe Hospital, Via Cadorna 90, 28824 Oggebbio, Verbania, Italy.
E-mail: p.capodaglio@auxologico.it

pears now important for Rehabilitation specialists to make some statements regarding what can be done rehabilitation wise to counteract the disabling consequences of severe obesity with comorbidities in the different settings at different intensities of rehabilitation treatment.

The aims of this review paper were therefore to review the determinants of disability in obese patients and to provide an up-to-date definition of hospital-based multidisciplinary rehabilitation programs for severely obese patients with comorbidities.

Intrinsic determinants of disability

Body composition

The overall increase in fat tissue affecting obese people has remarkable consequences on body composition and motor activity performance. In fact, compared with normal weight individuals, fat-free mass (FFM) is notably reduced in obese individuals on a per cent basis, but results significantly increased in absolute terms. Considering that FFM is an indicator, though rather approximate, of skeletal muscle mass, it follows that these very simple relations have relevant influence on the performance of the different kinds of physical activity. In fact, the larger muscle mass grants obese individuals a better performance during static (or quasi static) tasks requiring a significant development of strength, which is mainly determined by the size of involved muscles.[2, 3] By contrast, during vigorous movements entailing the rapid displacement of the body with a considerable power output under anaerobic conditions (such as stepping up a ramp of stairs or performing short sprints) the actual of performance is dictated by power output per unit body mass as determined by the ratio between the muscle mass and total body, which results particularly reduced in obese people.[4]

Skeletal muscle strength

As an adaptive response to increased body mass acting as a chronic training load during everyday movements, it has been established that overall leg muscle volume increases on average by about 2.4 kg every 5 BMI units in man and about 0.7 kg in females,[5] so that average obese men and women with BMI in the range of 35-40 kg/m^2 can rely on a lower limb muscle mass of about 20 and 12 kg, respectively, which compare with about 14 and 10 kg of normal weight men and women in BMI range between 20-25. Considering the lower limb muscle volume per unit body mass, which may be taken as an indicator of leg muscles available for the displacement of whole body during leg movements, these figures yield values of about 0.20 and 0.18 kg muscle/kg body for normal weight men and women, and about 0.18 and 0.12 for obese men and women. Accordingly, obese subjects display significantly more elevated absolute but lower relative (per unit body mass) muscle strength, torque and power output, obese women showing a particularly poor performance.[6-8]

Beside size, also muscle composition appears to have a relevant effect on strength performance. In fact, a higher degree of fat infiltration within muscles was observed with imaging techniques in obesity and older age [9, 10] and was found to be associated to reduced motor performances.[11-13] Thus, although muscle quantity is known to be the major correlate of force and power production on a general contest,[2, 3] qualitative attributes of muscle composition such as fat infiltration may be important descriptors of the association between muscle structure and function.

Balance

Apart from the effects induced by obesity on performance during physical activity, adipose tissue accumulation and body mass excess are a major factor contributing to the occurrence of falls. Indeed obese persons are reported to be at greater fall risk than normal-weight subjects during daily activities and postural perturbations.[14-18] Excessive body weight affects posture in linear proportion with the increase of BMI [19] and induces changes in several biomechanical parameters: larger forward displacement of the centre of pressure during dynamic standing balance activities,[20] augmentation of lumbar lordosis and pelvic forward tilt, more pronounced dorsal kyphosis and a secondary cervical lordosis.[21, 22] Frequently, internal rotation of the hips, knee valgism and flat feet coexist and the feet tend to splay apart during standing to optimise the centre of gravity and stability. Discomfort, pain and reduced tolerance to fixed postures, often consequences of a redundant mass, have been shown to affect posture.[21]

Maximal and submaximal aerobic exercise

It is common knowledge that performance during aerobic exercise is notably reduced in obese people, in terms of maximal velocity of locomotion or exhaustion time.[23] Nonetheless, as a consequence of augmented muscle volume or FFM, a higher maximal aerobic capacity (*i.e.*, the maximal oxygen uptake, VO_2) in absolute terms is often reported in obesity, although remarkably reduced when considered per unit body mass.[23,24] In practice, the execution of most modalities of motor activity require more mechanical work and demand more energy (i.e. submaximal VO_2) to obese than to lean individuals, by an amount proportional to the mass of the body parts involved in the required movements.[25] Therefore, the higher energy demand observed in obese individuals during submaximal exercise is related to the higher mechanical work required for the specific activity (i.e. the energy cost of the specific exercise), whereas the greater VO_2 attained at maximal exercise (even if corresponding to a lower maximal performance) may be considered the expression of a greater overall mitochondrial volume.

Energetics of locomotion and functional limitations

Being obese *per se* imposes functional limitations. During walking, the cyclical raise and acceleration of the body centre of mass at each step entails mechanical work in approximate proportion to the body mass, so that the subject's own weight results to be a determinant load. Therefore, obese people expend 1.8-2.3 fold more metabolic energy during walking than normal weight individuals, depending on degree of obesity, walking speed and ground incline.[25-28] Thus, for obese individuals, walking may be an exhausting task, requiring a considerable fraction of the individual's aerobic maximal capacity, scarcely sustainable by older and less fit individuals.[29]

Interestingly, when the energy cost per distance (*i.e.*, the metabolic energy per kilogram body mass to walk a given distance) is considered, the difference between obese and normal weight individuals is considerably reduced but not suppressed. In fact, different investigators detected values 5-15% higher in obese adults and adolescents as compared to their lean counterpart.[27-30]

Several biomechanical factors may explain the lower economy of obese locomotion. Spyropoulos *et al.*[31] observed an amplification of step width and hip abduction in obese individuals, which are known to imply a larger metabolic cost of walking.[32] During walking, obese subjects display a wider ankle dorsiflexion and lower ankle plantar flexion [31] altering the interplay between stretch and recoil of tendon/muscle tissue [33] and contrasting an efficient recovery of elastic energy at the end of the contact phase.[34] Moreover, the foot of obese individuals has a significantly reduced plantar arch height and produces large alterations in pressure distribution,[35] which also adversely affect foot mechanics during walking gait,[36] reducing the plantar aponeurosis deformation during foot contact and interfering the kinetics of elastic energy storage.[37]

Furthermore, according to different investigators,[38-40] body distribution of adiposity rather than body weight *per se*, might be an important determinant of the metabolic cost of obese locomotion. In fact, the extra mechanical work due to a larger momentum of inertia deriving from experimentally loaded limbs has been shown to contribute significantly to a higher cost of walking. However, the contribution of thigh mass to body mass ratio in obese subjects to the energetics of locomotion is still not clear.[28]

In conclusion, for obese people, the execution of short and rapid movements of chiefly anaerobic character is principally limited by the imbalance between the size of skeletal muscle and the size of the body, largely contributed by the abundant accumulation of fat tissue. By contrast, the aerobic performance is mainly limited by the high energy cost of moving the heavier body, or single body segments. Under this perspective, preservation/increase of skeletal muscle volume is a major priority during interventions aiming at the cure of body mass excess and the improvement of the motor capabilities of obese individuals. A net loss of muscle tissue would have in fact very negative outcomes on both anaerobic and aerobic function, especially in women who are inherently endowed with a lower amount of skeletal muscle relative to body mass.

Extrinsic determinants of disability: comorbidities

According to the Agency for Health Care Research and Quality in the US, we can define as "complex" a

patient affected by two or more chronic conditions which could mutually influence their outcome, by limiting life expectancy or the use of full therapeutic dose because of contraindications. Comorbidities are the prevalent causes of disability in obesity.[41] They can be divided roughly into three categories: 1) Conditions pathophysiologically linked to obesity; 2) pathologic conditions where obesity may act as a risk factor; 3) disease incidentally occurring in obese people but aggravated by the presence of the excess of body fat. Often, the distinction between (1) and (2) is difficult even for orthopedic comorbidities, but it may be useful from a clinical point of view. Epidemiological data on obesity comorbidities can hardly be found and moreover not all obese can be defined as disabled and not all comorbidities can lead an obese individual to be classified as disable. On the other hand, obese individuals may simultaneously complain of more conditions that may synergically act in determining disability. For these reasons the presence or the level of disability should be evaluated on an individual basis with appropriate approaches.

Metabolic conditions

Obesity is often associated with some of the following metabolic complications:

1) altered glycemic control:

— impaired glucose tolerance (IGT) glucose 140-200 mg/dL (7.8-11 mmol/L) at 2 hours after an oral glucose load;

— diabetes mellitus: fasting glucose ≥126 mg/dL (≥6.9 mmol/L) or ≥200 mg/dL (≥11 mol/L) at 2 hours after an oral glucose load;

2) altered blood lipids:

— total cholesterol >200 mg/dL (>5.17 mmol/L);

— HDL <40 mg/dL (<1.03 mmol/L) in men, <50 mg/dL (<1.29 mmol/L) in women;

— triglycerides >150 mg/dL (>1.69 mmol/L);

— LDL >130 mg/dL (>3.3 mmol/L);

3) hyperuricemia: uric acid >6 mg/dL (>360 µmol/L) in women, >6.8 mg/dL (>400 µmol/L) in men; there is a high risk of developing gout for values exceeding 9 mg/dL (535 µmol/L).

Other miscellaneous complications include: gastrointestinal system (gallstones, non-alcoholic liver disease, gastro-oesophageal reflux), endocrine function (infertility and sub-fertility), renal (glomerulosclerosis, proteinuria), venous and lymphatic circles (lymphedema, venous insufficiency, phlebytis) dermatological symptoms (intertrigo, achantosis nigricans, pressure ulcers, skin tags, hirsutism, *striae distensae*), neurological diseases (*pseudotumor cerebri*).

Obesity is characterized by a low-grade inflammatory state that is associated with an increased risk of atherosclerosis. More and more frequently an increase in FM is associated with a reduction of fat-free mass (FFM), a scenario termed sarcopenic obesity, which may carry the cumulative risk derived from each of the two individual body composition phenotypes.[42, 43] This is especially true for elderly subjects or in younger obese subjects with severe disabilities, following bariatric surgery without nutritional supervision and in response to long-lasting incongruous dietary regimen. A subject with sarcopenic obesity could often present with altered plasma proteins and immunocompetence parameters as for protein-calorie malnutrition [44] and organic complications. In addition, complications related to immobilization syndrome (pressure ulcers, venous thromboembolism) and/or reduced immunocompetence (respiratory sepsis) can occur.

The reduction in lean body mass can be evaluated in clinical practice through indices which relate the amount of lean body mass to body size or body weight (fat-free mass index); skeletal mass index, appendicular lean mass index: values lower than the mean-2SD of the value found in a control sample consisting of subjects aged <40 y are suggestive for sarcopenia.[45-52] In our view, a definition of sarcopenia based on the reduction of FFM in "absolute" terms is limited in the case of obesity. In this condition there is in fact, at least in younger adults, a physiological increase of FFM [53-56] which enables to maintain, for a relatively long time, a good metabolic control and a satisfactory physical efficiency. Nevertheless, signs of sarcopenia appear at an early stage in the obese subjects; as a matter of fact, a relative, and not an absolute reduction of FFM is sufficient to determine a reduced functional performance. It is therefore proposed, as an index of sarcopenia in obese subject, a reduction in the ratio actual FFM/ideal FFM <0.9. Studies to verify this threshold are underway.

Non-alcoholic fatty liver disease is the term that describes several liver pathologies associated with obesity, including hepatomegaly, elevated liver enzymes, and histological pictures ranging from simple

steatosis to fibrosis evolution to cirrhosis. The prevalences of steatosis, steatohepatitis, and cirrhosis has been reported to be approximately 75%, 20%, and 2%, respectively.[41] Cholelithiasis is the primary hepatobiliary pathology associated with overweight.[41]

Obesity may also affect the kidney. Glomerulopathy was significantly increased in pathological specimens compared with other forms of end-stage renal disease.[41] Specific forms of cancer are significantly increased in overweight individuals.[41] Males face increased risk for neoplasms of the colon, rectum, and prostate. In women, cancer of the reproductive system and gallbladder is more common. One explanation for the increased risk of endometrial cancer in overweight women is the increased production of estrogens by adipose cells. This increased production is related to the degree of excess body fat that accounts for a major source of estrogen production in postmenopausal women. The increased visceral fat measured by computed tomography shows an important relationship with the risk of breast cancer. A positive correlation between BMI and triglycerides has been repeatedly demonstrated as well as an inverse relationship between HDL and BMI. Waist circumference alone as well as waist/hip ratio or sagittal diameter, accounted for most of the variance in triglycerides and HDL cholesterol. Other lipid abnormalities have been described in obesity but it should be noted that a relevant proportion of obese paradoxically in the highest levels of BMI have normal lipid profile probably in relation to the prevalence of gluteo femoral fat that can contain a large amount of triglycerides thus preventing lipotoxicity.[57]

Type 2 diabetes mellitus is strongly associated with overweight.[41] The risk of type 2 diabetes mellitus increases with BMI levels, more pronounced visceral fat distribution as well as with the duration of weight excess. According with the data of Nurses Health Study at a BMI of 35 kg/m^2, the relative risk increased 40-fold. Similar data are reported for the Health Professionals Follow-Up Study. At a BMI above 35 kg/m^2, the age-adjusted relative risk for diabetes in nurses increased to 60.9, or more than 6000%. Up to 65% of cases of type 2 diabetes mellitus can be attributed to overweight. For the 11.7 million cases of diabetes, overweight may account for two-thirds of diabetic deaths.[41] A variety of endocrine changes are associated with obesity.[41, 58] Among these, the alterations of gonadal activity in both sexes have a clinical relevance in the comorbidities of obese individuals. Irregular menses and frequent anovulatory cycles are common, and the rate of fertility may be reduced. The presence of weight gain in polycystic ovary syndrome where insulin resistance plays a fundamental role is well known. Men also complain often of reduced libido associated with low testosterone levels and normal/low gonadotropins levels. A clinical and hormonal picture of functional secondary hypogonadism that often is difficult to differentiate from the organic forms. GH secretion is reduced with increasing BMI but whether this may have a relevance in the pathophysiology of fat deposition is unclear. Obesity is associated with increased cortisol production rate, which is compensated for by a higher cortisol clearance, resulting in plasma free cortisol levels that do not change when body weight increases.[58] Aldosterone secretion is correlated to BMI and it can be involved in the pathophysiology of insulin resistance.[59] Although obese subjects usually have a normal thyroid function, TSH and BMI are known to be positively correlated. In fact, many studies of children, adolescents, and adults have shown slightly increased TSH levels in obese individuals as compared to lean subjects.[60] By contrast, obesity increases susceptibility to autoimmune thyroid disease, with an emerging role of leptin as a peripheral determinant.[61] Other conditions such as gastroesophageal reflux, migraine, bronchial asthma are more frequent in obese patients but the pathophysiological meanings of these associations are still unclear.

Orthopedic conditions

Osteoarthritis is probably the most common obesity-associated pathology. In an old study,[62] 33% of 1,420 obese patients had radiographic evidence of knee osteoarthritis when evaluated over period of observation of about 30 years in the Framingham heart study. The link between obesity and subsequent osteoarthritis was obviously related to the degree of obesity. In more recent studies, however, the relevance of other metabolic and genetic [63] factors has been underlined. In a study on data collected in the health Survey for England and UK Back exercise and trial data [64] musculoskeletal illnesses evaluated in a sample of almost 9000 subjects were responsible for disability in 19% of the individuals but the prevalence increased form 14.6% in normal

weight to 30.3 in obese with BMI greater than 35. Joint degenerations leading to replacements at knee and hip level or spinal stabilization are frequent occurrences in morbid obesity. As for the relationship between obesity and osteoporosis and risk of fracture, epidemiological evidence shows that obesity is correlated with increased bone mass: subjects having larger body weight tend to have higher bone mass. However, when the mechanical loading effect of body weight on bone mass is adjusted for, the phenotypic correlation between fat and bone mass is negative. The risks of osteoporosis, osteopenia, and non-spinal fractures are therefore significantly higher for subjects with higher percentage body fat, independent of body weight.[65] Obesity has also been clinically implicated with other musculoskeletal disorders, such as ankle sprains, flat feet, *tibia vara*, slipped capital femoral epiphisis, and may have a profound effect on soft-tissue structures, such as tendons, fascia and cartilage. Obese people are two times more likely to develop carpal tunnel syndrome than are people of average weight, and women are three times more likely to develop it than are men.[66] When arising from a chair, they generally have to use their arms to push out of a chair: this extends the weight-bearing wrist, which may put additional pressure on the median nerve and also contribute to rotator cuff problems. The plantar fat pad is a specially organized and richly innervated adipose tissue that provides cushioning to the underlying foot structures of the heel, protecting the foot from local stresses during ambulation, dampening impulsive transients associated with heel strike. Increased stiffness and reduced compressibility of the subcalcaneal fat pad have been linked to the development of plantar heel pain.

Respiratory conditions

In general, obese subjects have a decreased work capacity if compared to normals. In fact, when studied at a progressive cycle-ergometer test, young obese subjects reach a maximal sustainable work capacity similar to that of normals, but an aerobic threshold (AT) at work rates significantly lower than those of normals; older obese subjects a significant reduced work both at AT and at maximal sustainable work capacity compared to normal.[67] Obese subjects need a greater amount of O_2 and produce a greater amount of CO_2 to accomplish the same external work-rate of normal.[67] Obesity is associated to a ventilatory functional impairment caused by a decrease in compliance of the respiratory system [68] and, at the same time, to abnormalities of cardiac left ventricular diastolic filling.[69] Under physical stress ventilation is apparently not a limiting factor to physical performance. Its increase during progressive exercise testing up to maximal sustainable work capacity is less than that in normal subjects, especially when related to FFM, but percutaneous oxygen saturation, in absence of concomitant pulmonary illnesses and in non extremely obese subjects, is constantly within normal ranges.[70] Ventilation seems appropriate to remove the increased amount of CO_2 produced at every power output ($PETCO_2$ similar between obesity and control), but, at the same time, lower than that required to fulfil the increased need for O_2 ($PETO_2$ constantly lower in obesity).[70]

During exercise, the increased transport and peripheral unloading of O_2 is assured by an increase of cardiac output (Q) together with a greater tissue extraction. The determinants of Q for a given VO_2 level are subject to large individual fluctuations whereas the Q/VO_2 relationship appears to be the same for all individuals in most experimental conditions.[71] In obese subjects this relationship displays a significant lower slope than in controls so that they have a reduced Q for the same VO_2 and must rely on a greater arterial-venous O_2 difference which means an increased peripheral extraction of O_2. This consideration agrees with the previous observations about the diagram Q/VO_2 and lower $PETO_2$.[72]

Obesity often aggregates with obstructive sleep apnea (OSA) and hypoventilation syndrome (OHS). Forty percent of obese subjects suffer from OSA, while those extremely obese (BMI >40 kg/m^2) up to 90%. The link between OSA and OHS is close, since about 90% of patients with OHS have OSA.[73] The concept of "adequate compensation" expresses a sustainable level of ventilation during sleep sufficient to prevent arousal which represents the "emergency exit" of the respiratory drive when the $PaCO_2$ is higher than scheduled. The main reasons of inadequate compensation in obesity includes: 1) an increased work of breathing; 2)an increased pharyngeal load by dilators muscles to oppose to pharyngeal collapse; 3) an attenuated response both to hypoxia and hypercapnia by the ventilatory drive.[74]

The treatment of choice is positive airway pres-

sure. This may be continuous at a constant prefixed flow (CPAP), bilevel where the device delivers a pressure in inspiration and a pressure in expiration independently, intermittent positive pressure or cycled where ventilators deliver a preset volume at pressures dependent on airway resistance.

Cardiovascular conditions

Coronary artery disease is the first cause of death in the developed world and is the fourth cause of disability accounting for 4.1% of disability adjusted life years.[75] Obesity per se is a relevant cause of disability.[76, 77] Obese subjects may have a specific cardiomyopathy due to increased circulating blood volume causes ventricular overload and therefore ventricular remodeling, endocrine abnormalities such as insulin resistance, increased activity of the renin-angiotensin-aldosterone system which in turn activates the sympathetic nervous system, but data on its prevalence cannot be found in the literature.[78] The link between obesity and atherosclerotic vascular disease is well documented. Prospective studies that have reported follow-up data over more than two decades, such as Framingham Heart Study, the Manitoba Study, and the Harvard School of Public Health Nurses Study, have documented that obesity, mainly if abdominal, is an independent predictor of clinical chronic heart disease.[41] Also in the report from the Nurses' Health Study the risk for U.S. Women of developing coronary artery disease is increased 3.3-fold with a BMI greater than 29 kg/m^2 compared with that in women with a BMI below 21 kg/m^2.[79] Weight gain also strongly affects this risk at any initial BMI.[80] Most hypertensive patients are overweight or obese. Hypertension is about six times more frequent in obese subjects than in lean men and women, in addition weight gain particularly in young patients is a relevant risk factor for hypertension The increase in blood pressure is more pronounced in people with abdominal obesity. In the Swedish Obesity Study, hypertension was present at baseline in 44-51% of the subjects. Key determinant of the weight-induced increases in blood pressure was a disproportionate increase in cardiac output related to an increase of sympathetic activity.[78]

Obesity is strongly related to heart disease and is part of a metabolic imbalance associated with an unfavorable cardiovascular risk profile. The prevalence of diabetes, arterial hypertension and dyslipidemia is high in obese subjects who are therefore at high risk for coronary artery disease.[81] A direct pathogenic effect of adiposity exists which acts through endothelial dysfunction, vasculopathy, and the proinflammatory status that derives from adiposopathy (*i.e.*, adipose tissue dysfunction) that characterizes obesity.[82] The eventual picture is characterized by the presence of left ventricular hypertrophy, diastolic and systolic dysfunction, altered autonomic balance, altered heart rate response to exercise, and a high prevalence of atrial fibrillation.

The activation of the renin-angiotensin-aldosterone and sympathetic nervous system contributes, together with sodium and volume retention, to the rise in blood pressure and exerts direct trophic effects on cardiac myocytes resulting in a progressive impairment of left ventricular filling and, subsequently, diastolic and systolic dysfunction that can eventually progress to heart failure. Insulin resistance has been linked to the development of early myocardial abnormalities in obese individuals, it promotes myocardial fatty acid uptake and can increase the levels of circulating angiotensinogen.

Ventricular remodeling and myocardial abnormalities associated to altered hemodynamics and loading conditions were the first factors identified in the pathogenesis of obesity cardiomyopathy. The high metabolic activity of adipose tissue and the increased lean mass of obese subjects lead to a circulatory state characterized by increases both in preload and afterload, which predispose individuals to left ventricular remodeling and dilatation, increase wall stress and therefore promotes compensative ventricular hypertrophy. The augmented wall stress causes concomitant increases in myocardial oxygen consumption, with eventual left ventricular dysfunction. Myocyte contractile dysfunction activates cardiac adrenergic drive, which initially compensates for, but ultimately contributes to remodeling and progressive contractile dysfunction. This peculiar hemodynamic situation has been described by Alpert.[83]

Heart failure with preserved ejection fraction is frequently associated with hypertension and obesity: it is currently considered as a combination of diastolic dysfunction and subclinical systolic dysfunction and has a poor prognosis which is only slightly better than the classical systolic heart failure syndrome. The whole picture of obesity cardiomyopathy includes also alterations of the right ventricular structure and function.[84] This is partly

due to the functional dependence of the ventricles but also to the high prevalence of OSAS. Almost every type of arrhythmia may be present in patients with sleep apnea: in particular ventricular ectopic beats, ventricular tachycardia, sinus arrests are prevalent.[85] The same is true for atrial fibrillation which is another condition with a high prevalence in the obese population [86] and can be detrimental in the hemodynamics of patients who already have diastolic dysfunction. The excess risk for atrial fibrillation associated with obesity, besides the presence of apneas, is related to left atrial dilatation which is very frequent in the obese.[87]

Psychological and psychiatric conditions

Psychological aspects of obesity have been significantly explored in recent years.[88] Even if several studies tried to investigate typical psychological profiles in obese persons, no obesity-specific personalities have been identified. Greater presence of psychopathology has been detected in obese persons in comparison with normal ones (for example more depression and suicidal ideation in obese women in comparison with normal-weight subjects).[88]

Particularly obese persons are strongly stigmatized and have to ceaselessly cope with explicit or implicit ways of prejudice and true discrimination about overweight and obese condition.[89] The consequences of this stigma are mostly social injustice and affected quality of life. Puhl and Heuer [89] reported the most frequent psychological consequences of the weight biases: "Weight bias increases vulnerability to depression, low self-esteem, and poor body image (moderate evidence), Weight bias contributes to maladaptive eating behaviors among obese individuals (strong evidence), Weight bias contributes to less participation/avoidance of physical activity (limited evidence)".[89]

Some studies underlined that employment settings could be affected by situations of stigma and discrimination, in fact obese employees were more negatively evaluated in comparison with non-overweight persons in the same working settings. This stigma is spread in the clinician settings too: physicians, psychologists, dieticians, nurses and other health care professionals can have and keep negative attitudes, beliefs and biases toward obese patients dedicating them not enough time to discuss and improve healthy lifestyles.[66, 89]

About the relationship between psychopathology and obesity there is no evident and clear knowledge: psychological disorders could be a cause and a consequence of obesity and this link has not yet been explained in an univocal way. Despite of this uncertainty, significant correlations between personality disorders, eating disorders, mood disorders, anxiety disorders and obesity have been underlined.[90, 91] Particularly this link is evident in some obese groups such as patients affected by high BMI (>35) [90, 91] and women.

About psychosocial stress, updated meta-analytic studies and reviews confirm that this factor could be positively linked with the development of obesity in prospective studies.[92] Particularly important moments of acute stress or life-events could play an important role in the etiology of obesity more in men than in women.[93] The relationship between obesity and psychosocial stress should be better investigated and explained.[92]

About depression, the relationship between obesity and mood disorders is gender dependent: obese women have an increased risk whereas obese men have a decreased risk.[94] Women with highest BMI have more probability (38%) to report clinically significant depressive symptoms in comparison with men, as studied in a large sample of adults (age 25-74).

Obesity could also be connected with eating disorders, particularly binge-eating disorder (BED).[96] Binge eating behaviors occur not only in overweight conditions but are more common in the obese than in normal-weight individuals.

About quality of life, obesity is typically connected with perception of disability, poorer control of symptoms, significant psychosocial impairment and more physical limitations in comparison with normal weight subjects. So obesity could create a situation of impairments not only in the physical health area, but also in the psychosocial functioning, psychological well-being and in the mental health field. Most significant deficits are present in obese patients who are severely obese (BMI >40), whereas moderately obese patients (BMI 30-40) have scores on psychological health scales that are similar to those of underweight people (BMI <20). In case of overweight women, scores on the same scales are similar to those of normal-weight subjects.[96]

Self-esteem could be affected by obesity, even if obese preadolescents and adults have a modest reduction, whereas adolescents' self-perceived over-

weight has a strong impact reducing self-esteem, especially for females. Body esteem is the area of self-worth that can be most compromised by obesity, especially for obese adolescents and young women, generating high levels of body dissatisfaction.[96]

According to, the most common psychosocial complications in adults are depression, low self-esteem, daytime sleepiness, fatigue, body dysmorphic disorder, social stigmatization, absenteeism and impaired quality of life, whereas in children and adolescents are lowered self-worth, body dissatisfaction, reduced cognitive function, behavioral disorders, depression, anxiety, substance abuse, restricted social networks and disordered eating.[97]

Measuring obesity-related disability

Unlike other medical conditions (hypertension, diabetes etc) obesity lacks of a quantitative definition. Its diagnosis should be based on the measure of fat tissue and its excess compared to a normal range. Body mass index (BMI), which is very useful for epidemiological purposes, does not measure fat and we have no data on the normal range of fat based on large epidemiological studies. Also, fat tissue is heterogeneus (visceral, abdominal-gluteal obesity) and yields different physiopathological implications. Given the lack of a quantitative threshold for grading the severity of obesity, the definition of the obesity-related disability therefore appears crucial for establishing rehabilitation needs and planning effective multidisciplinary interventions. Obesity is characterized by the coexistence of a chronic condition with multiple comorbidities and subsequent disability, similarly to what occurs in neurodegenerative conditions or in rheumathoid arthritis. Phases of disability may therefore occur in its natural history, requiring a here-and-now intensive multidisciplinary rehabilitation approach. Defining disability and its impact on quality of life becomes therefore important to assess the appropriateness of hospitalization and rehabilitation needs. Measuring disability with instruments reflecting the full range of functional status appears therefore crucial in order to initiate rehabilitation programs for obese subjects and to assess their effectiveness.

The ICF is a very comprehensive tool but its practice use in disability evaluation present some critical aspects due to its size and to its multi-factorial nature. An ICF Core Sets, a list of categories that are relevant to most patients with obesity, has been developed by Stucki [98] to define the typical spectrum of problems in functioning of patients with obesity and was subsequently implemented by Brunani *et al*.[66] The tests traditionally used in rehabilitation settings do not meet the requirements of complete evaluation because we need to distinguish functional limitations, in physical action used in daily life, from disability that is restriction also in social life: the Barthel Index, the Katz ADL Index, the Functional Independence Measures (FIM) and the Performance ADL Test assess very basic ADL. Others, such as the Sickness Impact Profile, the Instrumental ADL Scale and SF36, also assess mental and/or social functions but are not obesity-specific. In 2009, the Italian Society of Obesity (SIO) developed a new scale for assessing disability correlated to obesity in adult populations, the short-form questionnaire for Obesity-related Disabilities (TSD-OC),[39] intended to target the most important obesity-specific functional status dimensions such as physical, emotional functioning and social functioning. The TSD-OC showed better correlations with the SF-36 items related to physical component, although a significant correlation was also found with the items describing the mental health component,[99] suggesting that that disability in obesity is not only a physical issue. Its use within a multidisciplinary assessment should be implemented by specific instruments able to establish the role of environmental factors. This new scale may represent an important instrument for the description of obesity-related disability and for planning and measuring the effectiveness of rehabilitation programmes in obese subjects. Longitudinal studies [100, 101] have shown its sensitivity to change at different time points.

Also, given the frequency of the comorbidities associated with obesity, we can define the severely obese patient a "complex patient". To measure this complexity we should use, in addition to the aforementioned tools to grade the severity of obesity, specific disability scales and cumulative illness ratings to assess the functional consequences of the comorbidities.

Multidisciplinary rehabilitation program

Obesity is a long-term disease with high comorbidity with considerable impact on disability and

quality of life. Rehabilitation of such patients require a here-and-now multidimensional, comprehensive approach, where the intensity of rehabilitative treatments depends on the disability level and severity of comorbidities and consists of the simultaneous provision of physiotherapy, diet and nutritional support, psychological counselling, adapted physical activity, specific nursing skills. A multidimensional approach able to provide frontline assessment and preventive strategies, risk stratification, and disease management is needed and for that purpose, a team approach and the integration of several medical specialties, including clinical nutrition, endocrinology, psychiatry, and rehabilitation medicine encompassing different health professions, including dietitians, psychologists, physiotherapists and nurses is required. This is in line with the indications of the Italian Society of Obesity, [102] the 2010 consensus of the Italian Society of Obesity and the Italian Society of Eating Disorders [103] and the Italian Ministry of Health, who has recently acknowledged [104] the need for a rehabilitation pathway for severely obese patients with comorbidities. Those documents highlight the need for multiple rehabilitative settings according to the severity of disability, which calls for the need for multidimensional evaluation encompassing quality of life, disability, functioning and participation. The Individual Rehabilitation Project should therefore encompass different interventions and short- and long-term goals: 1) nutritional intervention; 2) motor/functional rehabilitation; 3) psychotherapeutic interventions; 4) rehabilitative nursing. Intensive hospital-based rehabilitation for obese patients usually consists of a four-week multidisciplinary program covering all those aspects. In a rehabilitation program for obese patients, weight loss is one of the main goal that has to be pursued through behavioral modification, diet and exercise [105] even if the results of such interventions are often disappointing. In addition to optimize the compliance to pharmacologic treatment guidelines, the long timetable of rehabilitation programs allows us to choose drugs that have a favorable effect on weight.[106] Rehabilitation is a setting in which patient-centered care can be vigorously implemented, empowering patients who no longer delegate physicians, but become protagonist in their health management.[107] Clinician-patient communication should be patient-centered to include the patient perspective and the psychosocial context along with shared understanding and responsibility. Health literacy improvement is another goal of rehabilitation programs: low health literacy, quite habitual in the obese, can result in decreased adherence to medical recommendations, failure to engage in healthy behaviors, and inferior outcomes. Quality of life should be one of the standard outcome measure of rehabilitation and it should be measured by disease-specific, patient-reported measures.[108]

Nutritional intervention and therapeutic education

It is important that nutritional intervention may contribute to correct previous unhealthy eating habits on a permanent basis. For this purpose there is need of frequent professional contact with the patient aimed at assessing the level of understanding of the given dietary recommendations given, the eradication of bad eating behaviors related to so called incorrect "dietary beliefs", the verification of the satisfaction level of the dietary plan (meal organization to suits the patient's needs; as far as reasonably possible, respect of customary dietary habits and tastes while encouraging at same time novel healthier choices).[109]

As a matter of fact, the nutritional intervention should be included into a process of therapeutic education. This is an essential phase in the management of chronic patients: the aim is to implement the knowledge about the disease and its management, and to change behaviours related to it for better management. In addition, therapeutic education allows to understand and to manage the psychological aspects related with the disease itself. Beside the role of providing the patient with information on practical aspects of disease management, therapeutic education also aims to help improve the patient's quality of life.[102]

The nutritional intervention is therefore designed to:

— inform about healthy nutrition and physical activity, with emphasis about regaining the physiological stimuli of hunger and satiety, recognizing the biological significance of food, rediscovering a sense of comfort with physical activity;

— train for managing and control nutrition and physical activity, even while under stress or in anxiety;

— train in the management and control of simple clinical parameters (*e.g.*, blood glucose, blood pressure);

— increase the sense of responsibility in illness and care (illness behavior);

— promote, strengthen and maintain sufficient motivation to change;

— contribute to the therapeutic compliance.

Therapeutic education for obesity must be guaranteed within the team, by professionals (doctor, nurse, dietician, community health educator, psychiatrist, psychologist, exercise physiologists) specifically qualified and trained for educational activity.[102]

Motivation is essential for obtaining adhesion to treatment and a stable weight loss. To this purpose, therapeutic education bases most of its intervention through techniques acting on conscious mental processes, some of which derived from cognitive-behavioral therapy, such as therapeutic alliance, problem solving and empowerment.[102]

Nutrition intervention will focus on:

1) achieving a weight loss of at least 10% from baseline body weight with a significant reduction in body fat and preservation of lean mass;

2) reconstructing long-term healthy eating habits (quality, quantity, rate) based on the canons of the Mediterranean Diet;[110]

3) obtaining a patient's compliance adequate to achieve the established objectives.

Functional rehabilitation

Obese inpatients undergo daily rehabilitation exercises to optimize muscle strength and the lean to fat mass ratio, increase joint range of motion and enhance cardio-respiratory conditioning. Since ostheoarticular pain at spine, hip and knee level is a major complaint and an obstacle to functional recovery in obese patients, physiotherapy focuses on joint unloading techniques, with the frequent use of taping, functional taping and sling therapy exercises,[111] passive and active lengthening and stretching of the muscular chains of the lower and upper limbs and the spine, strengthening and stabilizing of the lumbar trait, active and passive mobilization of the dorsal spine.[112] Manual lymphatic drainage and elastic compressive bandaging are also extensively used.

Resistance exercises aiming at muscle strengthening to reduce joint compression forces are performed 30 to 60 min daily. Their aim is also to improve balance by strengthening the heel stabilizer muscles.[113] Intensities of isotonic strengthening exercise are initially set at 40% of the individual 10-repetition maximum during the first week, 50% during the second week and 60% during the remaining rehabilitation period. The muscle groups to be trained are identified during the initial physiatrist evaluation. Strengthening supervised exercises with arms and legs include dynamic standing and floor calisthenics using body weight as movement resistance. A major priority of exercise prescription is to focus on activities which contribute to muscular fitness and preserve muscle mass. This goal seems important also in view of the effects of caloric restriction, which result in reductions of both fat and fat-free mass. Patients with severe motor limitations undergo physiotherapy and occupational therapy aimed at optimizing their capacities to cope with daily living activities through the use of walking aids, lifting and transferring devices.[114] Respiratory rehabilitation is very often part of the rehabilitation program and includes adapting and training patients and care givers to non-invasive ventilation.[111]

Adapted physical activity

A good activity program should entail both aerobic training, small bursts of anaerobic high intensity activity and strength exercise. Aerobic activity consists of cycloergometer, recline ergometer or armergometer (the choice depending on the presence of orthopedic problems). Based on the fact that a smaller muscle mass is used in cycling exercise to attain the same metabolic energy expenditure of walking,[115] with a greater metabolic stress and energy requirement per unit of contracting muscle,[116] it has been evidenced [25, 117] that walking is a convenient mode of exercise, compared to cycling. Walking permits in fact to attain any given energy expenditure at a comparatively lower average heart rate (or in a shorter time), with lower lactic acid blood concentration and higher fat oxidation. In practice, by some reckoning from these data comparing the metabolic responses of the two modalities, to obtain the energy expenditure of 250 kcal with a bout of 25-min activity, cycling should be performed at an intensity requiring an average heart rate of about 160 b/min with 3 g of lipids oxidation, whereas it will be sufficient to walk at intensity requiring an average heart rate of about 130 b/min, with over 11 g of lipid oxidation. Under this perspective, for obese individuals, inherently limited in their work capacity, it is very attractive to devise forms of physical activity enabling the attainment of a considerable energy expenditure by preference promoting substantial fat

oxidation with the lower subjective perception of effort and exercise intensity, which could ultimately allow a better tolerance and adherence to physical activity protocols.

The optimal duration of exercise is 30 minutes, or longer, to optimize fat oxidation.[118]

The effects of regular aerobic and resistance training on cardiovascular risk and general well-being are clearly demonstrated [119, 120] and increasing both intensity and duration exert a beneficial effect. Patients who are able to exercise to a level of 7.9 METs have lower rates of events. In our population, in a consecutive sample of 3728 obese patients, 732 were not able to perform a treadmill exercise test; of the remaining 2996 the vast majority reached a peak exercise level of less than 7.9 METs and only 620 patients (21%) exceeded that threshold. Exercise is safe and the risk of a cardiovascular event is very low in a cardiovascular rehabilitation setting.[121] Current guidelines recommend intensity range between 3 and 6 METs on most days of the week: this goal can be achieved by walking 30 minutes every day or walking 60 minutes every second day. Also cycling is a good exercise for obese subjects. Target heart rate during exercise has to be based on resting heart rate and peak heart rate during a symptom limited treadmill stress test. We use the formula *Target HR = Resting HR + (Peak HR – Resting HR) x 0.7* i.e. resting heart rate + 70% of the chronotropic reserve: that level of effort is generally associated with a "comfortable fatigue" sensation.

Patients also undergo a strength exercise program that is individualized considering patient's characteristics. They work for 45-60 minutes on a daily basis at low intensity and the main purposes of this activity are to increase muscle strength, to balance muscle tone and mass, to reach a good equilibrium between flexor and extensor muscles, to improve joint stability and mobility, to improve motor coordination, to improve body and motor patterns, and to relax both physically and psychologically.

A significant improvement in quality of life, as well as in life expectancy, can be achieved independently of weight change only because of regular exercise.[122] Cardiac rehabilitation causes a significant improvement in the cardiovascular risk profile at all levels of BMI, independently of weight loss. The issue whether it is weight or fitness that makes the difference has been addressed by Lee *et al.*:[123] they studied over 14,000 men and found that, for each 1-MET improvement, a 19% decrease in cardiovascular mortality was present, regardless of BMI or percent body fat change. Obese subjects who exercise regularly have a lower risk for metabolic abnormalities and their consequences than sedentary obese and represent the so called "fat-but-fit" phenotype. Considering that obesity is a chronic disease and therefore a complete recovery is not foreseeable, we can try to adopt the same concepts that we use when we treat other chronic conditions such as, for example, hypertension or diabetes, and set the "fat-but-fit" phenotype as a new target for obese subjects.[124]

Moreover caution on promoting unconditional weight loss may be safe, since obesity has a complex relationship with all-cause mortality and, in patients with congestive heart failure or coronary artery disease, the presence of obesity is associated with lower mortality when compared to normal-weight patients.[125] Therefore our target, even if most of the features that characterize the obesity cardiomyopathy can be reversed by means of weight loss, should mainly focus on the adoption of an active lifestyle which has a great impact on the prognosis of obese patients. For a weight loss intervention to be successful a negative energy balance must be attained; in this view, energy expenditure in the form of physical activity is an important part in the management of obesity for losing weight and reducing associated risk factors for chronic disease. Many formulas are recommended, principally in the form of "moderate intensity exercise" typically defined as 55% to 70% of maximum heart rate, 30 to 60 minutes day, five to seven days a week.[126] Less is known about advisable heavier intensities of exercise. With regard to this last topic, it has been observed that bouts of exercise beyond anaerobic threshold added to a program of aerobic activity significantly increase the release of growth hormone (GH) at a more extent than aerobic activity alone during physical exercise. This may be of some interest considering that GH is known as one of the most active substance able to ameliorate the ratio FM/FFM.[61]

Moreover, aerobic activity alone promotes a modest lowering of FM, a reduction in circulating non-esterified fatty acids and an increase in circulating lactic acid, with a reduction in insulin resistance for glucose. Bouts of added anaerobic exercise to an aerobic program promote a significant more important lowering in FM, an increase in circulating non-esterified fatty acids, a decrease in circulating

lactic acid, no modification in insulin resistance for glucose.

The drop in circulating non-esterified fatty acids after aerobic training may be the result of an imbalance between a slow mobilization of fatty acids from adipose tissue and their rapidly increased extraction by skeletal muscle, so demonstrating an increased oxidative capacity by the muscle. At the same time, the increase in lactic acid may be linked to the modified utilization of glucose due to the improvement in insulin sensitivity for it. The increase in circulating non-esterified fatty acids after aerobic plus anaerobic training may be due to an increased flow of substances with lipolytic activity after anaerobic stress (like GH, catecholamines etc.) which causes an excessive mobilization of lipids that probably exceeds their dynamic utilization. These observations may indicate the opportunity to initially prescribe aerobic with bouts of anaerobic training to decrease fat mass, and subsequently aerobic training alone to maintain the weight loss and ameliorate the metabolic profile. The exercise scheme "aerobic plus anaerobic" is probably inappropriate in obese patients with metabolic syndrome in view of the increase in serum non-esterified fatty acids and the lack of improvement in glucose metabolism.[127]

Psychotherapeutic intervention

As indicated in Cochrane systematic reviews,[128] a psychological therapy, particularly cognitive-behavior therapy including psycho-educational approaches, could be functionally combined with a nutritional intervention and physical activity plan increasing weight loss, if compared with the only diet/exercise intervention. The behavioral part of the therapy in obesity treatment is characterized by self-monitoring (for example, using diaries), stimulus control (for example, restricting quantities of food), and behavioral modification (for example, chewing slowly, taking time to really taste and enjoy the food, maximizing the pleasure from it).[129-131]According to other authors,[97,132] components of behavioural therapy for obesity could be specifically self-monitoring, problem solving, contingency management, stimulus control, stress management, social support from family members and friends and cognitive restructuring.

Moreover cognitive techniques could provide patients with useful strategies to accept realistic, but less-than-desired, weight losses. Relapse and weight regain could be generated by inappropriate feelings of failure after achieving modest but clinically important weight loss. It is focused on dysfunctional behaviors and cognitive processes, such as unrealistic weight goals and body image perceptions.[133]

The psychological intervention is a critical issue because the maintenance of weight loss after lifestyle modification, drug therapy, and weight loss surgery is more likely to depend on behaviour modification and enduring psychosocial support. Long-term behavioural therapy is more successful than short interventions.

Cognitive-behavioral approach represents the gold standard for the treatment of obesity, but other interventions are growing and are collecting new evidences. Hypnosis could also be used, with particular patients, enhancing them in correcting dysfunctional thoughts, attitudes, and beliefs.[134, 135]

Other promising psychotherapies used for the obesity treatment are the interpersonal approach,[88, 136, 137] the systemic and strategic treatments,[138-141] the psychodynamic approach [142] and the feminist-theories based treatment.[143-145] Another promising treatment for the psychological rehabilitation of obesity is the mindfulness approach, as described by Kabat-Zinn,[146, 147] using meditation to control food cravings.[129, 148] Also be the EMDR approach could be an interesting treatment.[149]

Rehabilitative nursing

Rehabilitative nursing is aimed at stimulating patients' reaction to chronic conditions and disability, functional and social skills to improve participation to the rehabilitation program. Nursing bed-ridden obese patients is more time-consuming than assisting lean patients, particularly in demanding tasks such as bodily hygiene, where nurses can spend up to twice the time than with lean patients.[150, 151] Critical aspects related to bariatric nursing are: the need for adequate figures of healthcare providers, the concern for both the patient's and the provider's safety, the lack of bariatric equipment in standard Units, the patient-professional relationship, both at personal and professional level.[152, 153]

PATIENTS' HANDLING

The following characteristics of the patient orientate the choice of intervention and level of assistance

(number of operators, time, number of transfers etc) and should be carefully evaluated both during the admitting assessment and on a regular basis:

— BMI: if > 35 risk of injury increases both for operator and patient;

— weight distribution can severely affect safety and manouvres the patient is able to perform and is crucial in choosing appropriate aids;

— collaboration during the manoeuvre;

— weight bearing capability on the lower limbs. Incapacity to bear weight on the legs increases the risk of fall for the patient and of injury for the operator. Mechanical aids can alleviate the problem and a targeted strengthening program should be initiated;

— upper limb strength, which is needed in various manouvres (lean and push for performing sit-to-stand, grab handles, lean on aids for balance);

— capacity to understand instructions and simple commands, which are needed when collaborating to manoeuvres;

— pain (*i.e.*, presence of wounds, contractures etc) can affect the manouvre and limit movements causing an extra-effort for the operator, who in turn should know in advance where pain is localized in order to reach comfortable positions for the patient;

— orthostatic hypotension or anxiety should be borne in mind, since its presence suggests cautious and slow movements;

— tolerance to effort is reduced in obese patients, who may suddenly feel the need to sit down or find support, thus increasing the risk of fall;

— respiratory problems can become more evident during manouvres with aids and in certain positions;[154] this can increase anxiety in patients who may respond with brisk reaction movements;

— orthopedic conditions (hip, knee replacements etc) require avoiding manouvres at risk of dislocating the joint, but also amputations, osteoporosis, spine stability require special attention;

— neurological conditions (*i.e.*, paralysis post-stroke etc., multiple sclerosis etc.) require careful evaluation.

Manual handling of the patients should be avoided as much as possible and patient's collaboration and participation encouraged, also by using adequate bariatric aids which minimize the risk of musculoskeletal injury. Bariatric beds, chairs, lifting devices, walkers etc should be part of structurally appropriate wards and facilities.[114]

Self-care

When the patient is partially dependent in self-care, the nurse has to define his/her capacity in the different areas of feeding, personal hygiene, dressing, toileting, to stimulate improvements in independence. Difficulties in personal care and hygiene are mainly due to movement limitations or secondary to architectural barriers or lack of perceived need for hygienic care. The interventions planned by the nurse range from ergonomic adaptations of the environment to the assistance in/execution of hygienic care tasks. The nurse provides the minimum degree of supervision or direct assistance needed by the patient to safely and correctly perform daily tasks. Personal hygiene is often hindered by the excessive body mass and the deep skin folds, specially in part of the body which are not easily accessible to inspection: perineal, breast, abdominal and lower limb folds are common sites for developing pressure sores and skin conditions. To provide adequate hygiene, an adequate number of healthcare providers and bariatric aids are needed.[155]

Mobility limitations

Walking, capacity of negotiating stairs, transferring from bed or moving around with the wheelchair, using the toilet and the shower are impaired in the severely obese patient. To counteract these mobility limitations, the nurse, together with the rehabilitation team, should evaluate architectural barriers, plan and perform postural changes in bed, educate to the correct use of aids and to injury and fall prevention. Reduced tolerance to physical activity in obese subjects can also be related to mechanical breathing difficulties and early fatigue. The nurse together with physiotherapists and adapted physical activity specialists should help promoting physical activity bouts on a daily basis, teaching "energy saving" and "joints unloading" techniques to increase activity levels and tolerance to effort. Reduced tolerance to effort can hinder the execution of basic daily activities, and simple gestures such as leaning forward to pick up objects, reaching upwards, lacing shoes may become very difficult.

Risk of fall

Risk of fall is higher in obese patients as compared to their lean counterparts.[156] High scores on specific

balance scales (*i.e.*, a score >2 on the Conley scale) document the increased risk of fall in these patients. The nurse, together with the occupational therapist, should plan dedicated prevention and education interventions for patients and relatives/care givers. Teaching patients how to perform steadily and safely postural changes, how to use toilet/shower/tub are crucial aspects of these interventions. The nurse should also monitor and assist patients treated with diuretics or laxatives, specially at night time. Educating to the correct use of transferring and mobility aids is a very important duty of nurses and physiotherapists. As for risk of falls, patients have to be reminded to use non-slippery shoes and to avoid brisk movements and postural changes, architectural barriers should be removed and adequate night lighting provided.

Management of comorbidities

When diabetes is present, it is important that the nurse monitor glycaemia in order to capture signs and symptoms of hypo/hyperglycaemia, evaluate hydration, pharmacological therapy and nutrition. Specifically, the nurse educates the patient to inspect the skin and the eventual diabetic foot, to self-monitor glycemia, to correctly adhere to the hypoglycaemic therapy, to follow a correct nutritional scheme, to accomplish consistent exercise bouts and to recognise early signs and symptoms of hypo/hyperglycemia.

Among the associated conditions, the risk of infection and skin conditions such as dermatitis, ulcers and delayed cicatrisation play an important role. Possible strategies are: use fewer barriers between the critically ill patients and bed to reduce friction, use a flat sheet instead of the fitted sheet, use a moisture wicking underpad, instead of the heavy pink pads, to reduce friction and the enable easier movement of the patients, reposition patient by sliding flat sheet along a maximum inflated mattress.[157]

Incontinence correlated to obesity is usually related to high intra-abdominal pressure, but can also be related to external factors, such as difficulty of sitting on an adequately sized commode. Medical management of severely obese patients include an assessment for OSAS. Patients with OSAS require assisted ventilation at night, which may improve a range of aspects of quality of life, related cardiac arythmia, hypertension, daily drowsiness with the related risks at work and during driving. C-PAP or BI-PAP treatment implies that the nurse together with physiotherapists choose the most suited facial or nasal mask and help the patient understand the importance of ventilation in order to achieve a satisfactory quality of life. Compliance to ventilation and management of all the components of the device at home should also be part of the assessment. The nurse should check the patient's position during sleep, the correct adhesion of the mask to the face to avoid ineffective ventilation and prevent pressure sores. Effectiveness of ventilation has to be measured with oxygen saturation level at night and eventually oxygen therapy can be added to ventilation.

Critical measurements

Measuring blood pressure with standard-size cuffs (13 cm-wide, 32 cm-long) is one of the most common causes of error in the indirect measurement of blood pressure. The cuff should be wrapped round the intermediate part of the non-dominant upper limb. Specific bariatric cuffs (15 cm x 30-35 cm) should be used.

ECG recording can be difficult because the adipose tissue in the thoracic region hinders the correct positioning of the electrodes on the anatomical landmarks. Abnormal positioning can indeed lead to formulate wrong diagnoses. Copious sweating and large breasts can also hinder electrodes positioning. The supine position is often uncomfortable and dyspnoea may arise, also as a result of anxiety and mechanical difficulty in breathing, with secondary abnormalities or artefacts on the ECG tracks. Measuring body weight, height, waist circumference and BMI is crucial to define the nutritional status. Body composition (lean mass, fat mass, water), as assessed by bio-impedentiometry, should also be measured. Body weight can be measured with both electronic or mechanic weighing scales: floor-mounted standard scales with lateral supports for measuring weight in standing position, chair- or bed-scales, lifts with built-in scales. The choice of equipment depends on the patient's residual functional capacities and the frequency of measurements. The following points should be addressed when weighing patients: fully inform them, weighing in the morning before breakfast and always at the same time and under the same conditions, help them to get undressed and onto the scale, avoid leaning on any surface other than the scale during the measurement, include aids when weighing patients who regularly use canes, walkers or braces.

Conclusions

The variable disability and health status of obese patients and the complexity of the multidisciplinary interventions call for the definition of different rehabilitation settings. In particular, severe obesity with disabling comorbidities requires admission to hospitals with appropriate organizational and structural competences. According to a hub-and-spoke model, such hospitals should be linked in a continuum of care to facilities in the territory providing rehabilitation treatments at lesser intensity. Hospitalizations may occur for acute events or diagnostic-therapeutic purposes (i.e. hip replacement or diagnosis of a neoplasm) or relapse of a chronic condition (i.e. COPD). Such conditions may eventually lead to a subsequent admission to rehabilitation Units. Rehabilitation is also needed when disability cannot be managed by the care givers at home or nursing homes. Inpatient rehabilitation programs have shown to be effective in the short- and medium-term.[158] However, since obesity is a chronic condition, such programs should be continued at the appropriate intensity in the long run. Long-term and follow-up results are now needed to document the effectiveness of such approach and the impact on health costs. This will help shaping a cost-effective strategy for counteracting the disabling consequences of obesity.

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