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The role of body position and gravity in the symptoms and treatment of various medical diseases

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Summary

Postural medicine studies the effects of gravity on human body functions and the ability to influence various diseases by changing the body's position. Orthostasis requires numerous cardiovascular and neurohumoral adaptations to prevent hypotension and a resulting decrease in cerebral perfusion. Sitting upright or in a semi-sitting position reduces venous return in patients with heart failure, intracranial pressure in patients with intracranial hypertension, intraocular pressure in glaucoma patients and may decrease gastro-oesophageal reflux. A left recumbent posture also decreases reflux. A right lateral position results in a lower sympathetic tone than lying on the left side and is beneficial in patients with heart failure or after an infarction without bradycardia. A 40 to 70% decreased prevalence of the sudden infant death syndrome has been observed since the recommendation to avoid laying infants to sleep in a prone position. Sleeping in a supine posture increases the severity of sleep apnoea compared to a lateral position. In patients with acute respiratory distress syndrome, a prone position can rapidly improve blood oxygenation. Idiopathic oedema, orthostatic proteinuria, intradiscal pressure and venous circulation in legs are improved in the decubitus position, whereas arterial flow is reduced. Health risks due to microgravity and prolonged bed rest, such as osteoporosis, venous thrombosis or pressure sores, are discussed.

Key words: postural treatment; body position; gravity; circulatory and respiratory disease

Introduction

Gravity imposes numerous cardiovascular (CV) and neurohumoral adjustments on the human body in the standing position. Physiological adaptations mainly due to the effect of gravity occur during changes of position and can influence the symptoms of various diseases involving not only the circulatory system but also other systems (respiratory, digestive, osteoarticular etc). In this paper the effects of different postural changes on these systems and their clinical relevance are reviewed. Spectacular examples of these are the decrease in cot deaths since avoidance of the prone position in sleeping babies was introduced and the rapid improvement in blood oxygenation when patients with acute respiratory failure are placed in a prone position. These improvements cannot be explained by the effects of gravitational forces on the respiratory system alone. In this review however we assume that gravity is the main force involved in postural changes.

We selected references by searching articles published in the past 20 years in PubMed under each subheading of the review using the key words body position or body posture. Articles with practical medical implications have been selected.

Effect of gravity on the cardiovascular system

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The pressures in this system are measured with reference to the atmospheric pressure and the reference point is right atrial pressure, which at rest is remarkably stable and close to 0 mm Hg. Taking a resting recumbent young 180 cm tall, adult male as the normal standard, the mean arterial pressure at the level of the heart is close to 100 mm Hg. The gradient in the arteries due to friction (gradient = flow × resistance) is of the order of 5 mm Hg. Thus the mean arterial pressure at the level of either the foot or the head is expected to be 95 mm Hg. On the venous side, the gradient in veins is in the order of 3 mm Hg, thus the venous pressure at the level of either the feet or the head will be close to 3 mm Hg. In the erect posture, these pressures are very different. Hydrostatic pressure occurs in the vascular system because of the weight of the blood in the vessels. The effect of gravity, i.e. the positional hydrostatic factor, is equal to $\mathbf{p} \times \mathbf{g} \times \mathbf{g}$ dynes/cm^2 where **p** is the blood density (1.05 g/cm^3), **g** is the acceleration due to gravity (980 cm/sec^2) and **h** is the distance (height) from the reference point in cm. This is negative for levels above the reference point. To convert dynes/cm^2 into mm Hg the result must be divided by 1360.

The hydrostatic factor is calculated as $(1.05 \times 980) / 1360 \times h = 0.76 \times h$. The pressure is thus decreased in any vessel located above the level of the heart and increased in any vessel under the heart. In the erect position the arterial pressure at the level of the heart is close to 100 mm Hg. The pressure in cranial arteries 60 cm above the heart is 49 mm Hg (95–0.76 × 60) and the pressure at foot level, 120 cm under the heart, is 186 mm Hg (95 + 0.76 × 120). On the venous side, the right atrial pressure does not vary more than 1 mm Hg following postural change. The one point where the hydrostatic pressure is not affected by changes in body position is at the level of the tricuspid valve. Heart pumping capacity adapts to filling pressure (the Starling effect) and prevents any hydrostatic change at this level. In an adult standing absolutely still a pressure as high as 94 mm Hg (3 + 0.76 × 120) can be measured in the foot veins. In the neck the veins collapse under negative pressure. However if the right atrial pressure increases by as much as 10 mm Hg, the veins in the lower neck begin to protrude and at 15 mm Hg all the veins in the neck become distended, this being a sign of heart failure. Immediately after standing there is a distension of the venous system (due to its greater compliance) under the heart, which corresponds to a rapid accumulation of 300 to 800 ml of blood in the legs and a lower venous return. The cardiac output as well as the arterial pressure (pressure = flow × resistance) fall. The latter is detected by the arterial baroreceptors. Their activation results in stimulation of the sympathetic system and heart rate and contractility increase helping to maintain the cardiac output. In the longer run there is a stimulation of the renin-angiotensin -aldosterone system as well as norepinephrine (NE) secretion. The arterioles constrict helping to maintain blood pressure (BP). In the cerebral circulation because of an efficient autoregulatory system, blood flow is stable for variations of arterial pressure between 60 to 140 mm Hg. When cerebral flow decreases below 60% of the flow measured in a decubitus position, signs of cerebral ischaemia appear [1].

Heart failure, orthopnoea and trepopnoea

Orthopnoea is defined as dyspnoea that develops in the recumbent position and is relieved by elevation of the upper body. In decubitus there is reduced pooling of fluid in the lower extremities and abdomen. Blood is displaced from the extrathoracic to the intrathoracic compartment. A failing left ventricle is unable to pump the extra volume of blood delivered by the right ventricle without dilating and there is an increase in venous and capillary pressure causing interstitial pulmonary oedema, reduced pulmonary compliance, increased airway resistance and dyspnoea. Orthopnoea can be relieved immediately by sitting upright on the edge of the bed with the legs dependent. In contrast, attacks of paroxysmal nocturnal dyspnoea may require half an hour or longer in this position to provide relief. Paroxysmal nocturnal dyspnoea is due to bronchospasm, which may be caused by congestion of the bronchial mucosa and by interstitial oedema compressing the small bronchi, resulting in increased ventilatory difficulty [2]. The mechanisms of this bronchospasm are still poorly understood. Expiratory flow limitation aggravated by the supine position has been observed in patients with acute left heart failure [3]. In patients with chronic left ventricular failure, a large rise in airflow resistance after lying supine for five minutes has been measured using forced oscillation. This cannot be attributed to a reduction in lung volume when supine and there is no evidence of vagally induced bronchoconstriction. This rise of resistance is reversible within five minutes of resuming the sitting position [4].

Trepopnoea is a rare form of orthopnoea limited to one lateral decubitus position. It has been attributed to distortion of the great vessels in certain positions [2]. A milder form occurs in chronic left heart failure (CHF). Patients feel more dyspnoeic when they sleep in the left lateral position and they spend significantly less time in this position [5–8]. In a study of 12 patients with CHF, spectral analysis of heart rate variability was analysed and NE concentrations were measured. The right lateral decubitus position was preferred for significantly longer periods than the left lateral and supine positions. Sympathetic modulation was most attenuated in the right lateral position and NE levels were lower than in the decubitus position, whereas the serum level of atrial natriuretic peptide (ANP) was higher [7]. Other studies using spectral analysis of heart rate variability have confirmed that the sympathetic tone is lower (and the vagotonic tone higher) in the right lateral position [9]. The reasons for this are unknown. Kuo et al. [9] speculate that, as the heart is left sided, it is located in a higher position in the right lateral decubitus position and thus the pumping of blood to the body is easier. As the right atrium is situated in a lower position in the right decubitus position, this position facilitates greater venous return via the vena cavae and higher filling pressure resulting in a greater cardiac output and higher serum levels of ANP. Indeed an increase in preload and cardiac index and a decrease in systemic resistance in the right position have been observed by others during laparoscopic surgery [10]. A higher PaO_2 has been measured in the right lateral position compared to the decubitus position in postoperative coronary artery bypass graft patients [11]. Patients with mild CHF prefer the right position which increases the venous return, whereas patients with severe CHF prefer a sitting position to reduce venous return [7]. Kuo et al. [9] have proposed the use of the right lateral decubitus position as an effective physiological vagal enhancer in patients with severe coronary heart disease or after infarction without bradycardia.

Influence of arm position on measurement of blood pressure (BP)

In both normotensive and hypertensive patients, measurements made with the arm pendent (vertical) are consistently higher than those made with the arm supported horizontally at heart level. In a population of 90 hypertensive patients the average BP was 156/95 mm Hg supine, 145/90 when seated with the arm horizontal and 156/102 when seated with the arm pendent. The mean difference in sitting BP averaged 11/12 mm Hg [12]. The differences can be predicted from the formula for calculating hydrostatic pressure. As 1 mm mercury pressure equals 1.36 cm H_2O, a distance of 13.6 cm below the heart results in an increase of 10 mm of Hg [13]. This is of practical importance during 24 hour ambulatory measurement of BP. During the night BP readings obtained while subjects are lying with the cuffed arm up are about 10 mm Hg lower than those obtained when they are in the supine position or with the cuffed arm down [14]. It is also relevant when measuring BP at the wrist. If the wrist is located under the level of the heart it will overestimate BP. The position of the wrist during the measurment is one of the factors that could explain the low agreement of wrist BP to the classical humeral measurement in some studies [15].

Orthostatic hypotension, oedema and proteinuria

In normal supine young subjects active standing up induces a drop in systolic and diastolic pressures and an increased heart rate during the first 10 seconds followed by a rise of BP after 20 seconds. After standing for one to two minutes the systolic pressure is similar to supine and the diastolic pressure rises by about 10 mm Hg [16]. Orthostatic hypotension is defined as a decline of 20 mm Hg or more in systolic BP and of 10 mm Hg or more in diastolic BP on assumption of an upright posture [17]. It has been observed in 4% of subjects aged 56–65 years, in 25% aged 66–75 years and 36% aged 75–85 years. Tachycardia induced by orthostatis becomes increasingly less common beyond 55 years of age. It could reflect decreasing sensitivity of the baroreceptors with advancing age [18]. Elastic stockings may be helpful in the treatment of orthostatis, if they cover the thigh as well as the calf. The head of the patient's bed should be elevated 5 to 20 degrees to prevent nocturnal diuresis and supine hypertension that result from nocturnal shifts of interstitial fluid from the legs into the systemic circulation [17].

In patients with orthostatic oedema, which is the most common form of idiopathic oedema, fluid retention may induce weight gain during the day (as much as 1 to 5 kg) whereas normal subjects gain an average of 0.46 + 0.04 kg from morning to evening. Orthostasis induces fluid retention and impaired sodium excretion due to a decrease in ANP and stimulation of the renin-angiotensin-aldosterone system. The latter could be activated by excessive orthostatic transudation through abnormal capillaries into the lower parts of the body. Patients are advised to reduce the number of hours spent in the upright posture and to lie down at least for the time between their evening meal and bedtime. Elastic stockings or leotards are effective in preventing excessive gravitational pooling of blood in the lower limbs and thus reducing oedema formation [19].

Protein excretion is invariably greater, regardless of the condition, in the upright than in the recumbent position. However people with orthostatic proteinuria (usually less than 2 g/24 h) have complete normalisation of their protein excretion in the recumbent position.

The mechanisms of orthostatic proteinuria are unknown but altered renal haemodynamics leading to increased glomerular filtration are believed to play a role [20].

Arterial insufficiency

It is well known that in severe peripheral arterial disease rest pain may be present overnight in the decubitus position due to ischaemia and this improves when the legs are placed in a dependent position. In a study of patients with arterial insufficiency, measurement of forefoot subcutaneous blood flow in the decubitus position showed a larger decrease in patients with ischaemic nocturnal rest pain than in patients without pain (32% versus 16%). As the simultaneous measurement of mean arterial pressure showed a similar decrease (19%) in both groups, the authors concluded that nocturnal hypotension was the major aetiological factor in the ischaemic nocturnal rest pain [21]. Blood pressure decreases during the night during the non REM sleep due to reduced activity of the sympathetic nervous system, a 10% decrease of BP is usually observed. In contrast, in REM sleep, BP returns to levels similar to those during wakefulness [22]. In a study of patients with arterial insufficiency, placing the leg in the dependent position increased the transcutaneous oxygen tension from 14 to 33 mm Hg at room air and from 21 to 53 mm Hg with 0_2 inhalation (10 l/min). It has been suggested that placing the limb in the dependent position may augment $TcP0_2$ to levels where symptoms may resolve [23].

Venous insufficiency

In a standing position the venous system is distended. Chronic venous insufficiency has been diagnosed in 29% of 387 male workers with a profession requiring upright posture [24]. The risk of thromboembolic event is increased among patients with extended bed rest [25] and even after prolonged sitting as illustrated by the «economy-class syndrome» [26]. The risk of pulmonary embolism is much higher among passengers travelling more than 5000 km [27]. Symptomless deep venous thrombosis may occur in up to 10% of long-haul airline travellers. The risk of thrombosis can be reduced by wearing elastic compression stockings during long flights [28]. Compression therapy of the legs, at a pressure of 30 to 40 mm Hg, reduces the effect of gravity on venous congestion by accelerating linear flow in the deep veins of the legs [29]. Although it is less convenient, leg elevation has also been proposed prophylactically to decrease the risk of thrombosis and to treat patients with chronic venous insufficiency [30, 31]. In such patients the change from an upright to a supine position can elicit an instantaneous increment in the blood flow rate of 30–40% with a decrease in the central and postural sympathetic vasoconstrictor activity [32]. On the other hand, on changing from the horizontal to the sitting position there is a reduction in arterial flow to the skin of the foot due to reflex reduction in blood flow caused by an increase in peripheral resistance. This could explain the improvement of skin oxygenation in the supine position compared to the standing [33].

Cutaneous circulation and pressure sores

The incidence of pressure sores in bedridden patients in hospital is reported to be as high as 6–20% [34]. Among the extrinsic factors, excessive compression of the soft tissues between a bony prominence and the surface of the bed (interface pressure) is well recognized. If this external pressure exceeds the capillary pressure in the arterioles by more than 32 mm Hg, the perfusion pressure is interrupted, resulting in ischaemia. If an external pressure higher than 70 mm Hg is maintained for more than 2 hours, it may induce irreversible cutaneous damage [35]. If this pressure is relieved for 5 minutes every 2 hours the risk of lesions is decreased. This risk can be reduced by regular changes of body position and by local massages to activate the circulation. It can also be decreased using pressure decreasing mattresses [34].

Respiratory system

Hydrostatic pressure is due to the weight of the blood in all the vessels including the pulmonary arteries. In the upright adult the lowest point in the lungs is about 30 cm below the highest point. This represents a 23 mm Hg pressure difference. Since blood is denser than the gas-containing lung, the effects of gravity are much greater on the distribution of blood flow than on the distribution of tissue forces in the lung. From apex to base the effective perfusion pressure of the pulmonary circulation increases by about 1 cm H_2O/cm vertical distance, whereas pleural pressure increases by only 0.25 cm. In the standing position there is little flow in the top of the lung but about five times this flow in the lower lung where venous pressure exceeds alveolar pressure. Therefore at the top of the lung there is an increase in the ventilation-perfusion ratio causing a moderate degree of physiological dead space. In the bottom of the lung there is a decrease in this ratio representing a physiological shunt. Deviation from this gravity-dependent pattern has been called vascular redistribution. It can be observed in left heart failure. When a person is in the lying position no part of the lung is more than a few centimetres above the level of the heart. The blood flow is then comparable to the flow in the lower lung in a standing position [1, 2].

Sudden infant death syndrome (SIDS)

In western countries, SIDS (sudden infant death syndrome) or cot death is the leading cause of death in the first year of life after the neonatal period. The aetiology is unknown and probably multifactorial. Prolongation of the QT interval in the first week of life is associated with a 40 fold increase in the risk of SIDS [36]. In the seventies, it was recommended that children be placed in the prone position in order to decrease the risk of aspiration after regurgitation. In the following years, Dutch data showed that the incidence of SIDS had more than doubled. This was confirmed in a number of retrospective studies. In the eighties it was then recommended that healthy infants be positioned on their sides or backs to sleep. The rate of SIDS has declined by 40% to 70% following a «back to sleep» campaign in the Netherlands and other countries [37, 38]. The prone position does not seem to decrease the ventilation-perfusion matching and may even reduce gastro-oesophageal reflux [39]. However the prone position raises arousal and wakening thresholds, reduces autonomic activity, decreases pharyngeal space and increases the collapsibility of the pharynx compared to the supine position [40, 41]. Other factors have also been shown to potentiate the detrimental effect of the prone position: the use of natural-fibre mattresses, swaddling, recent illness and the use of heating in bedrooms [38]. Lateral positioning may also decrease the rate of SIDS, although less efficiently than the supine position, but as this position is less stable and could impair the development of the hip some paediatricians recommend the supine position [38]. On the other hand the «back to sleep» campaign has resulted in an increased incidence of posterior deformational plagiocephaly, particularly unilateral flattening of the occiput [42].

Obstructive sleep apnoea

This condition affects 2 to 4 percent of middle-aged adults. It is characterized by at least five episodes per hour of sleep of airflow cessation for more than 10 seconds. It is associated with a decrease of more than 4% in oxyhaemoglobin saturation. Apnoea is due to narrowing or closure of the upper airways (hypopharnyx) occurring mainly during REM sleep [43]. The hypotonia of the upper airway muscles during this stage of sleep favours the closure of the muscle in the supine posture. This posture produces an augmentation of the severity of sleep apnoea [44]. Even in non positional obstructive apnoea, apnoeic events occurring in the supine position are more severe than those occurring in the lateral position [45]. In order to avoid the supine position during sleep, it is recommended that a tennis ball be sewn into the back of the pyjama top.

Acute respiratory distress syndrome (ARDS)

ARDS is characterized by radiographic diffuse bilateral infiltrates, decreased respiratory compliance, small lung volumes and severe hypoxia. It is associated with a very high mortality rate. Several studies have shown that placing the patients in a prone position improves oxygenation by 69% within 30 minutes among 297 patients with ARDS [46, 47]. Patients with hydrostatic pulmonary oedema benefit from the prone position contrary to patients with pulmonary fibrosis [48]. Several mechanisms have been proposed to account for the improvement of oxygenation, including an expansion of gravity induced atelectasis, an increase in end-expiratory volume, better ventilation-perfusion matching and correction of venous stasis. However in a randomized study comparing patients in the supine position to patients placed in a prone position seven hours daily for 10 days, the survival rate did not improve in the prone group and the mortality rate was 60% at six months in both groups [49]. The conclusion of this study is that either the prone position provides no benefit or its duration (10 days) too short to produce an observable influence on survival.

Unilateral lung disease: down with the good lung?

In a study of patients with severe hypoxaemia due to unilateral pneumonia, lateral position had a striking effect on PaO_2 which increased from 100 mm Hg ± 14 mm Hg in the supine position to 156 ± 23 mm Hg at maintenance FIO_2 when the abnormal lung was placed uppermost [50]. These data confirm previous studies in patients with unilateral lung disease [51]. When the diseased lung is inferior, gravity could accentuate the perfusion of unventilated areas with a consequent increase in shunting. However, the opposite effect has been observed in patients with unilateral central airway lesions. In these patients, when the normal lung is inferior it is possible that the obstruction of the lesioned airway becomes more severe or that secretions from the lesioned lung enter the normal lung and decrease its ventilation [52].

Digestive system: gastroesophagal (GE) reflux

Symptomatic GE reflux affects up to 40% of the adult population. It is due to a failure of the barrier function between the stomach and the oesophagus allowing an excessive reflux of gastric content into the oesophagus. This reflux results in oesophagitis and in up to 20 percent of patients complications may develop, such as strictures or columnar metaplasia. GE reflux is primarily due to transient and simultaneous relaxation of the lower oesophageal sphincter and the crural diaphragm. The period of relaxation lasts 10 to 60 seconds. Gastric distension, upright and right lateral decubitus positions and meals high in fat increase the frequency of such relaxation [53]. In patients with oesophagitis, moving from the recumbent to the upright position decreased the number of GE reflux events six fold. Reflux was eight times more likely to occur in the right recumbent position. Indeed, the right lateral position places the GE junction in a dependent position so that liquid gastric contents collect above or near the submerged GE junction. In the left lateral position, liquid gastric contents lie in the dependent part of the stomach and only gas is present at the GE junction for reflux into the oesophagus, as demonstrated by radiographs after barium [54]. In another study, right lateral decubitus was associated with greater percentage of time with pH <4 and longer oesophageal acid clearance compared to the left, supine and prone positions [55]. This could lead to a higher incidence of reflux episodes caused by an increased incidence in transient relaxation of the lower oesophageal sphincter [56]. In children, the prone position can also decrease the GE reflux [39] but this position is not recommended in children less than 2 years old because of the increased risk of cot death [38]. In 71 patients with grade III oesophagitis, sleeping with the bed-head raised was able to decrease retrosternal pains and to improve the endoscopic aspect of the oesophagus as efficiently as treatment with ranitidine. The combination of the two treatments was much better than either alone [57].

On the other hand, four randomized trials have shown that the semi-recumbent position compared with the supine position is associated with less GE aspiration and pneumonia in patients receiving mechanical ventilation [58].

Osteo-articular system

Diurnal variation in stature

The time of the day when the height of a person is measured is important in serial height assessments. A person is tallest on rising in the morning and shrinks by 0.5–1.5 cm during the day [59]. Measurements of standing heights in children show a decrease in stature during the morning. In a study of fifty children the mean height losses were 0.31 cm for the period 9 am to 11 am, 0.2 cm from 11 am to 1 pm and 0.045 cm from 1 pm to 3 pm [60]. Another study recorded a maximal height loss of 1.4 cm between morning and afternoon measures [61]. The standard stretch technique does not appear to reduce diurnal variation. It is recommended that children be measured in the late afternoon if accurate growth rate is required.

In a study of 50 adult volunteers, significant standing height decrease (>6 mm) occurred during the course of the day, while subjects showed a height increase (>5 mm) after lying supine for an average period of 49 min [62]. The decrease in stature during the day is believed to be due to the flattening and/or to the loss of water content of intervertebral discs in the standing position.

Posture and discopathy

Pain due to herniated intervertebral discs usually increases in the sitting position compared to standing or decubitus position [63]. In vivo intradiscal pressure has been measured in 8 healthy subjects and in 28 patients with back problems, using an advanced pressure sensor. The spinal load increased in the following order of body positions: prone 144 Newton (N); lateral, 340 N; upright standing 800 N; upright sitting 996 N. In the standing and sitting position, the spinal load increased not only with forward bending but also with backward bending. The intradiscal pressure in the degenerated discs was significantly reduced compared with that of normal discs [64]. Although pain decreases in the prone position, bed rest is not recommended for more than 4 days for the treatment of low back pain or sciatica [63].

Osteoarthritis

Ten percent of people over 60 years old suffer from osteoarthritis. Peripheral articulations (hands) are affected as well as weight bearing articulations (knees, hips). Although genetic factors play an important role, they are modulated by mechanical factors such as body weight [65]. Knee osteoarthritis is more prevalent in overweight women and in women who wear high-heeled shoes. The latter induces an increased force across the patellofemoral joint [66]. In a study of older obese women with osteoarthritis of the knee, weight loss combined with exercise led to a decrease in pain and disability. There was also a decrease in the levels of biomarkers of cartilage degeneration such as keratin sulphate, interleukin-1 and proteoglycan [67].

Osteoporosis

When the skeleton is non weightbearing because of spinal-cord injury, neuromyopathy, bedrest or microgravity, about 1–2% of the bone mineral density at selected skeletal sites is lost each month. Immobilization osteoporosis is a major problem in patients confined to chronic bed rest [68]. In a study of 12 weeks of bed rest in normal subjects, a bone mineral density decrease of 0.95% per month in the greater trochanter has been reported. Urinary calcium increased from 5,3 mmol/day to 73 mmol/day during bed rest [69]. The increased mobilisation of calcium from bone leads to a decrease in secretion of parathyroid hormone, an increase in urinary calcium secretion and a lower level of 1–25 vitamin D, which prevents the intestinal absorption of calcium. Exercise, static longitudinal compression of the skeleton by the placement of a load of 80% of bodyweight at the shoulders, negative pressure on the lower body did not prevent the negative calcium balance associated with the reduction of the mechanical forces stressing the skeleton due to bed rest [70]. In space, despite physical training, a bone loss of 0,9% per month in the tibial cancellous envelope and 0,3% in the tibial cortex has been observed in cosmonauts [71]. Little is known about how much G force is needed for normal osteoblastic function and about the mechanisms by which loading of bone is perceived and translated into signals controlling bone formation. The possible roles of locally produced factors such as IGF-1, BMP and TGF beta must be further elucidated [72, 73].

Brain and eye

Intracranial and intraocular pressure

The normal pressure in the cerebrospinal fluid (CSF) system when lying in a horizontal position averages 130 mm H_2O (10 mm Hg) but it may vary between 65 and 195 mm H_2O in a healthy person. Variations in pressure depend on the position of the body. The pressure can be negative (lower than the atmospheric pressure) in a standing position. In patients with intracranial hypertension it is common practice to elevate the head of the bed to 30 degrees [74]. This may have a beneficial effect on intracranial pressure (ICP) via changes in mean arterial pressure, airway pressure, central venous pressure and CSF displacement. In a study of 22 head-injured patients, when the patient's head was elevated at 30 degrees, the mean ICP decreased from 19.7 to 14.5 mm Hg but the mean carotid pressure also decreased from 89 to 84 mm Hg without a change in cerebral perfusion pressure (CPP) [75]. However in certain circumstances (hypovolaemic patients with haemodynamic instability) head up position may reduce mean arterial pressure, which in turn will result in a paradoxical rise in ICP through autoregulation mechanisms [76]. In most patients with intracranial hypertension, head and trunk elevation up to 30 degrees is useful in helping to decrease ICP, provided that a safe CPP of at least 70 to 80 mm Hg is established. Patients in a poor haemodynamic condition are best nursed flat [74].

Glaucoma

The intraocular pressure rises when body position is changed from sitting to supine [77]. In a study of different patients, changing from the sitting to the supine position increased the intraocular pressure by an average of 4.4 mm Hg in the control group, 4 mm Hg in patients with ocular hypertension and 4.1 mm Hg in patients with low tension glaucoma [78]. This augmentation could be due to a pressure increase in episcleral veins. In another study determining the visual fields, changing position from supine to upright induced an improvement of visual field in normal subjects but a slight deterioration in glaucoma patients. These findings and other data indicate that some glaucoma patients exhibit faulty regulation of central retinal artery blood flow during posture change [79].

Bed rest and microgravity

Bed rest is often advised for various medical conditions such as myocardial infarction, psychiatric disease, operation, serious infections etc. However, a recent review of studies recommending prolonged bed rest has shown an increase in the risk of deep vein thrombosis, bedsores, osteoporosis and pneumonia [25, 34, 68, 80]. Nowadays a shortening of prescribed bed rest has been advised in patients with myocardial infarction, gestational hypertension, viral hepatitis or acute back pain [63, 80].

Studies of cosmonauts in microgravity have shown «a contrario» the role of gravity in human physiopathology. The changes caused by microgravity include bone demineralization, skeletal muscle atrophy, vestibular problems causing space motion sickness, cardiovascular problems resulting in post flight orthostatic intolerance [81]. An analysis of these side effects is beyond the scope of this review. However, it is interesting to note that a six degree head down tilt and water immersion to the neck have been utilized to simulate the cardiovascular effects of microgravity. During both of these interventions, there is a fluid shift from the lower extremities to the upper body leading to an increased venous return, stimulation of volume and pressure receptors and a decrease of NE, renin and aldosterone [82, 83]. Stimulation of central volume receptors in the walls of the atria causes diuresis in normal subjects and in patients with fluid retention. In 14 patients with hypoalbuminaemic fluid retaining states the mean rise in urine volume was 69.5% greater in the supine than in the sitting position and in the head down position it was 80.3% greater than in the supine position [84]. A similar diuretic effect in patients with cirrhosis has been obtained with head-out water immersion [83], which is able to induce the release of ANP [82, 83].

In conclusion, «postural medicine» deals with the different effects of gravity on the human body and with the physiopathological changes resulting from various body positions. Postural changes induce cardiovascular and neurovegetative adaptations as well as variations in the pressure of internal fluids such as cerebrospinal fluid. Therefore improvement in intracranial or intraocular pressure resulting from the sitting position may be limited and even antagonized by simultaneous changes in the cerebral or retinal circulation. Contradictory data come from haemodynamic studies in lateral positions depending on the type of disease and the duration of the new position. The right lateral position could be beneficial in patients with heart failure or after myocardial infarction but not in patients with gastro-oesophagal reflux. The cause of the decrease in the activity of the sympathetic system in the right lateral position is not clear. The respective roles of the baroreceptors and of the vestibular system should be clarified [85].

When caring for our patients, we should not forget the utility and side effects of the omnipresent force, gravity.

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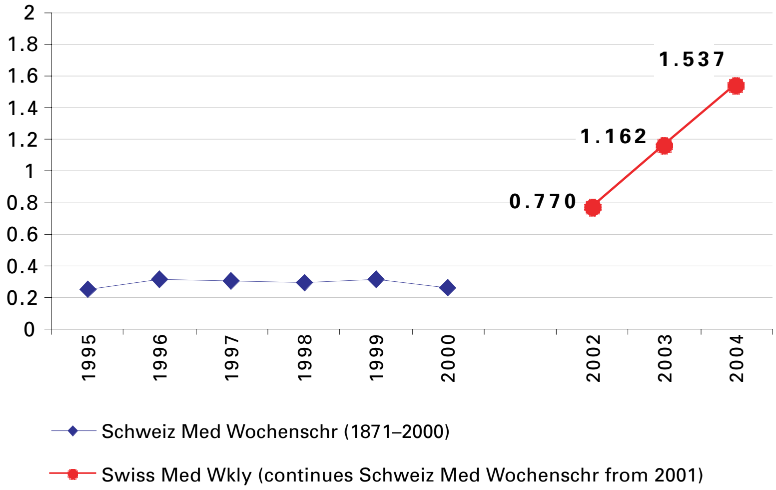

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