Compression across the sizes

A literature review compiled by Rosemary Kendell, Clinical Advisor, Jobskin
for the ANZBA ASM 2019, Hobart Tasmania

Underweight, overweight, and obesity in childhood and adolescence are associated with adverse health consequences throughout the life-course. (NCD Risk Collaboration, 2017).

The NCD Risk Collaboration reviewed 2416 population-based studies with measurements of height and weight on 128·9 million participants aged 5 years and older, including 31·5 million aged 5–19 years. Change over the period 1975 to 2016 was mapped by region and showed the following

- Flattening trends in mean BMI in NW Europe, high income English-speaking and Asia-Pacific regions for both sexes, SW Europe for boys and central Latin America for girls.
- Increases in BMI have accelerated in east and south Asia and Southeast Asia for boys.
- Globally the prevalence of obesity increased for girls from 0.7% (0·4–1·2%) in 1975 to 5.6% (4·8–6·5%) in 2016, and for boys from 0.9% (0.5-1.3%) to 7.8% (6.7- 9.1%).
- The prevalence of moderate and severe underweight decreased from 1975 – 2016, from 9.2% (6.0-12.9%) to 8.4% (6.8-10.1%) for girls, and from 14.8% (10.4-19.5%) to 12.4% (10.3-14.5%) in boys.
- The prevalence of moderate and severe underweight was highest in India at 22.7% (16·7–29·6%) among girls and 30·7% (23·5–38·0%) among boys
- The prevalence of obesity was more than 30% in girls in Nauru, the Cook Islands, and Palau; and boys in the Cook Islands, Nauru, Palau, Niue, and American Samoa in 2016.
- The prevalence of obesity was 20% or more in several countries in Polynesia and Micronesia, the Middle East and North Africa, the Caribbean, and the USA.
- In 2016, 75 million girls and 117 million boys worldwide were moderately or severely underweight. In the same year, 50 million girls and 74 million boys worldwide were obese.

Ross (2014) suggests that currently 30% children under 18 years are overweight and 16% are obese. Reich Schupke (2105) suggests that 70% of Micronesian, Tongan and Cook Islanders are overweight, 2/3 of the US population are overweight, and 32% are obese. In Germany, 60% men and 40% women are overweight. The global prevalence of underweight decreased from 14.6% to 9.7%, and the prevalence of obesity increased from 6.4% to 14.9% among women from 1975 to 2014 (Seo et al 2018).

Literature search strategy

A literature search was undertaken, using the keywords 'compression therapy', 'compression garment', 'obesity', 'morbid obesity', 'overweight', 'underweight', 'burn', 'scar'

Unit 1, Level 1, 100 Station St
Nunawading VIC 3131
AUS: 1800 772 577
NZ: 0800 765 627
www.jobskin.com

Obviously pressure gradient delivered during this type of treatment determines efficacy, and complications that may be due to excess pressure or incorrect pressure gradient application. Pressure garment therapy has been known to cause overheating, pruritus, blistering, wound breakdown, and abnormal bone growth (Atiyeh 2013)

Garment construction

There are two standard methods used for garment design and construction. The Reduction Factor method is the most commonly used and reduces a patient's circumferential measurements by a certain percentage without taking into account the fabric tension when calculating garment dimensions. The second method uses the Law of Laplace based on the circumferential measurements of the patient and the tension profile of the fabric. This is more accurate, but difficult to utilise manually. The standard reduction factor is constant and is not normally changed on the dimensions of the body part being treated, or the specific properties of the fabric. The more frequent and accurate the measurements, the better the garment is likely to fit the patient. However, as the curvature of a body part varies for different bodily forms, large discrepancies in garment pressure may result from different patients when a constant reduction factor is used for that body part for all patients. Plus since no body part is a uniform cylinder, pressure exerted by a garment with a given tension is not uniform and is distributed differently over the various areas of the body for any given patient. (Atiyeh 2013)

Macintyre (2007) affirms that the most fundamental limitation for the efficacy of compression is the standard reduction factor as it is not normally changed based on the dimensions of the body part being treated or the specific properties of the fabric.

The theory of Laplace's Law was originally developed to relate the wall tension and *radius* of cylinders (e.g. blood vessels) to the difference that existed between the pressure pushing the two halves of the cylinder apart and the wall tension pulling the two halves together. The origin of the use of the using Laplace's law for estimating pressure delivered by pressure garments is unclear. First reference is in 1984 (Puzey) and its use was based on the observation that the measured pressure increased over areas of low radius of curvature, decreased on areas of high radius of curvature and was nil on concave areas. However, when patients are measured, the *circumference* is measured, not the radius. Therefore it would be more useful if Laplace's Law was amended to predict pressure from the fabric tension and circumference of the body part.

The proportions and weight of nylon and elastane in a powernet fabric largely determine its tension delivery potential, therefore, the tension of varied powernet fabrics should be inherently different. However, fabric tension also changes under extension. As the tension in a fabric increases, the pressure that it exerts increases.

Laplace's Law accurately predicted all the pressures exerted on cylinder models by pressure garments with different fabric tensions at a set circumference so potentially can be used as a basis for a designing process at a set circumference.

For quality assurance of pressure garments, the tension of every fabric to be used in garment construction should be measured at a minimum of nine extensions. This allows for predictability of the pressures that a pressure garment would exert.

Unfortunately the relationship between body circumference and the pressure exerted has not yet been scientifically established and published.

The standard practice in garment design of applying a single reduction factor to all body circumferences will result in graduated pressure being applied to patient's limbs by normal

- Pressure exerted by clothing adversely affects certain aspects of the normal physiological balance –dietary carbohydrate absorption (Sone, Kato, Kojima, Takasu and Tokura 2000), rectal temperature (Lee, Hyun and Tokura 2000), and blood pressure (Harumi, Miyuki, Hideo, and Kiyokazu 2001). Bras exerting >75mmHg had a negative impact on autonomic nervous system activity.
- The effects of percentage body fat, age, sec, race etc. on the interface and/or subdermal pressure delivered using similarly constructed garments are not fully understood. (Macintyre and Baird 2006)
- Patient compliance - low compliance with PCT is to be expected (given….) (Atiyeh 2013)
- Only 60% of pressure garments fit perfectly the first time and 40% require adjustments. Reported compliance for head and neck pressure garments is only 44%, and patients usually apply the garments no more than 10-14 of the prescribed 23 hours/day. (Atiyeh 2013)
- Adherence also compromised by negative effects of visible burns disfigurement, issuing of pressure garments after hypertrophic scarring had developed, lack of patient choice in the selection of scar management techniques, and lack of social support in the wearing of pressure garments. (Atiyeh 2013)
- Much of what is traditionally understood as 'patient non-adherence' are deliberate choices made by patients in the face of difficulties they experience with the form and nature of their PG therapy. (Atiyeh 2013)
- Increased perspiration when wearing pressure garments. Many burn patients live and work in hot conditions with high levels of perspiration. Investigated impact of moisture content on fabric tension. Elastic fabric for pressure garment construction will deliver significantly higher pressure when they are dry than when they are wet. Therefore if fabrics are likely to be wet during wear, this should be taken into account during garment design. This study considered the sort-term effect of wetness, but perspiration may have longer detrimental effects not known. Impact of perspiration on long-term pressure delivery is not known (Macintyre et al 2016)

Garment Fit

The fit of the garment is a major factor that determines the pressure exerted on the skin and therefore the likely success of failure of the treatment. As previously noted, custom—made garments fit better than ready-to-wear pressure garments.

Macintyre (2006) notes specific considerations in garment fit –

- Garments should extend at least 2" (5cm) beyond the margins.
- Softer fabrics applying less pressure can be used for the first set of pressure garments to ensure fragile wounds do not reopen under the pressure of normal pressure garments. Newly healed scar tissue is very fragile and sudden movements may tear the skin.
- Double-layered pressure garments can be used to apply higher pressures.
- Pockets or Velcro for attaching additional padding can be inserted in areas where adequate pressure is not being achieved.

Of particular note is that the subjective feeling of pressure may be reduced if skin strain is reduced. Double layered pressure garments that reduce shear pressure may enable higher pressures to be tolerated by patients. (Macintyre 2006)

Longevity of compression

All pressure garments lose tension and therefore pressure delivering ability over time and use. Pressure garments designed to exert greater pressures degrade faster than those designed to exert lower pressures. Furthermore, contact between pressure garments

and moisturisers accelerate tension degradation. Machine washing tends to prolong their pressure-delivering properties compared to hand-washing. Since pressure garments are expensive, to provide more effective pressure therapy, it is essential that the best possible product is supplied to patients in terms of better fir, fewer alterations, less likelihood of stretching, and component parts that are less likely to cause discomfort or deterioration.

Despite precise fitting techniques, pressure garments do not provide a consistent amount of pressure at the scar/garment interface. It should be noted that studies reporting results of pressure therapy without verifying the amount of pressure applied are of limited value. (Atiyeh 2013)

The Issue of Obesity

Obesity was officially declared by WHO as a global issue in 1997 after the morbidity associated with obesity was accepted. Currently the most important risk factor contributing to health burden internationally. Its co-morbidities include non-insulin dependent diabetes mellitus (NIDDM), hypertension, dyslipidaemia, stroke, coronary heart disease, and certain types of cancers. For hospital admissions, weight has been examined as an essential predictor of morbidity and mortality.

Obesity is described in literature as a factor that has contributed to poor outcomes and more severe complications in burns patients alongside other risk factors such as extremes of age, and diabetes. Obesity has been established as a vital risk factor in critically ill patients after major injury. Various studies have examined the relationship of obesity to various complications – increased adiposity creates alterations to physiological processes which create challenges. Patients are predisposed to wound infections, increased LOS, increased Lo ICU stay, and an increased number of burn-related operations.

Discussion of adiposity and physiological processes incl.

- Wound healing
- Increased mortality
- Increased pulmonary embolism
- Little evidence/literature re. paediatrics and obesity except IV access and airway stabilisation

The literature, even burn-specific, fails to provide any discussion regarding scarring outcomes, but concludes that obesity is a chronic pro-inflammatory state which potentially worsens the outcomes and increases the prevalence of complications in burns patients. Sayampanathan 2016 demonstrated that obese patients had higher odds of increased mortality rates and length of stay.

Over the last decades, notion of obesity being a state of lipid deposition has changed to hypothesis of low-grade chronic systemic inflammatory disease, which mimics an 'acute-phase reaction' observed in critical illness.
The key physiological system alterations brought about by obesity, include
Cardiac – hypertension, cardiomyopathy, potential fluid overload in resuscitation phase, and impacts exercise tolerance in rehabilitation phase
Respiratory – high diaphragmatic position coupled with an increase in chest wall fat and enhanced volume of blood in pulmonary circulation. High likelihood of obstructive sleep apnoea with vulnerability to apnoeic episodes, desaturation. Obese children more prone to sleep-related respiratory compromise. Sleep disturbances have the potential to affect long-term rehabilitation through behavioural implications.
Gastro/hepatic – altered gastrointestinal motility, non-alcoholic steatohepatitis
Renal – excess adipose tissue plus hypertension plus diabetes mellitus leads to an increased risk of renal failure

Haematological – increased risk of thromboses
Pharmacological - implications for the absorption, distribution, metabolism and excretion of drugs
Immunological – adipose tissue is an active endocrine organ and modulator of immune function
Metabolic changes
Endocrine – altered hypothalamic function. Endocrine aberrations in obese patient can have profound effects on rehab including scar quality. Routine measurement is recommended to control prolactin secretion and its scar sequelae.

Management of the obese burn patient

Obese patients are more prone to entrapment when they sustain a burn injury, which has the potential for a deeper depth of injury and an increased likelihood of concomitant inhalation injury. An altered rule of nines is required for assessment, given the altered proportion of the body. Adipose tissue can be poorly perfused and has a decreased tolerance to hypoxia and ischaemia. Morbid obesity is associated Vitamin D deficiency which contributes to an increased inflammatory response.
Obese patients also have a risk of excessive weight gain during rehabilitation

- Behavioural issues – difficulty moderating oral intake, decreased activity, social isolation, emotional overeating which has been noted to increase since the UberEats phenomenon
- Biochemical – prolonged persistence of an inflammatory state

Obesity is associated with lower functional outcomes – lower functional scores, increased likelihood of discharge to care, lower FIM scores (Goutos et al 2012)

There is a paucity of literature regarding scarring outcomes in relation to obese patients either from articles written regarding burns and obesity (Liodaki et al 2014, Monstrey et al 2014, Ray et al 2015, Ross et al 2014) OR regarding the impact on obesity on best practice/scar management guidelines (Khansa et al 2016, Sharp et al 2016).

Obesity and related comorbidities (diabetes, hypertension, respiratory and cardiac insufficiency) predispose an individual to surgical and post-injury complications not otherwise encountered. The normal predictors of outcomes are affected by obesity.
In adults, obesity associated with higher rates of bacteraemia, sepsis, pneumonia, length of stay, ventilator days and mortality. However, obesity in the paediatric population is not associated with the usual comorbidities and do not present the same problems for caregivers. (Ross et al 2014) Liodaki 2014 identified that obese patients are likely to have increased tension at wound edges with an associated high incidence of wound dehiscence, seroma and haematoma.

Compression and obesity

The article 'Compression therapy in obese patients' by Reich-Schupke (2015) is the only article specifically about compression and obesity.
Obesity is associated with an increased risk of venous and lymphatic disorders, both of which in themselves require compression therapy. Usually the correct choice of material and wearing the garments on a daily basis pose a greater problem than the manufacture. Simply withholding compression therapy from this growing patient group ("It won't fit anyway") is not an alternative. Obese patients with complications are reliant on compression to manage these complications.
Important questions to ask include -

- Previous weight development
- Mobility, exercise possible during compression therapy
- Motivation for consistent adherence to compression therapy

BMI is a major factor in determining independent donning, one possible solution is to consider more than one garment, i.e. segmenting the garments.

Compression therapy for obese patients is often associated with skin complications - constriction, congestion, blisters, erosions and ulceration. These frequently result from slippage or poor fit, so regular pressure checks are recommended.
Hygiene issues are common for obese patients wearing compression and include tinea, and erythrasma or erysipelas (triggered by skin cracks). Regular use of antiseptic washes are recommended particularly in the groin, below the breasts, under abdominal aprons and in deep skin folds. These areas need to be kept dry and protected from macerations by padding with gauze compresses.
Irritation and intolerance is common. Dark colours and components of adhesive edges can precipitate contact allergies but intolerance is more likely to be the result of irritation from poor fit, poor skin care or chafing and garment slippage.

References

Atiyeh BS, El Khatib AM and Dibo SA *Pressure Garment Therapy (PGT) of burn scars: evidence-based efficacy.* Ann Burns Fire Disasters 2013 26(4) 205-212

Fricke NB, Omnell ML, Dutcher KD, Hollender LG and Engrav LH *Skeletal and dental disturbances after facial burns and pressure garments*. The Journal of Burn Care and Rehabilitation 1996 17(4) 338-345

Goutos I, Sadideen H, Pandya AA and Ghosh SJ *Obesity and Burns* Journal of Burn Care and Research 2012 33(4) 471-482

Khansa I, Harrison, B and Janis J *Evidence-based scar management: how to improve results with technique and technology*. Plastic and Reconstructive Surgery 138(3S)165S-178S 2016

Leung WY, Yuen DW, Ng SP and Shi SQ *Pressure prediction model for compression garment design*. Journal of Burn Care and Research 2010 31:716-727

Liodaki E, Senyaman O, Stollwerck PL, Mollmeier D, Mauss KL, Mailander P and Stang F
Obese patients in a burn care unit: a major challenge. Burns 40 (2014) 1738-1742'

Macintyre L. *Designing pressure garments capable of exerting specific pressures on limbs*. Burns 2007 33 579-586

Macintyre L and Baird M *Pressure garments for use in the treatment of hypertrophic scars - a review of the problems associated with their use*. Burns 2006 32 10-15

Macintyre L, Dahale M and Rae M. *Impact of moisture on the pressure delivering potential of pressure garments*. Journal of Burn Care and Research 2016 37(4)365-373

Macintyre L and Ferguson R *Pressure garment design tool to monitor exerted pressures* Burns 2013 39 1073-1082

Monstrey S, Middelkoop E, Vranckx JJ, Bassetto F, Ziegler UE, Meaume S and Teot L *Updated scar management pratical guidelines: Non-invasive and invasive measures*. Journal of Plastic, Reconstructive & Aesthetic Sugery 2014 67 1017-1025

NCD Risk Collaboration. *Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults.* Lancet 2017; 390: 2627–42

Rappoport K, Muller R and Flores-Mir C *Dental and skeletal changes during pressure garment use in facial burns: a systematic review.* Burns 2008 34(1) 18-23

Ram S, Abraham A, Hauben DJ and Calderon S *Effect of facial pressure garments for burn injury in adult patients after orthodontic treatment.* Burns 2001 27(4) 409-412

Ray JJ, Satahoo SS, Meizoso JP, Allen CJ, Teisch LF, Proctor KG, Pizano LR, Namias N, Schulman CI *Does obesity affect outcomes of adult burn patients?* Journal of Surgical Research 2015 198(2): 450-455

Reich-Schupke S *Compression Therapy in obese patients*. Plebologie 2015 44:71-76

Ross E, Burris A and Murphy JT *Obesity and outcomes following burns in the paediatric population*. Journal of Paediatric Surgery 49 (2014) 469-473

Sayampanathan AA *Systematic review and meta-analysis of complications and outcomes of obese patients with burns*. Burns 2016 42 1634-1643

Sharp PA, Pan B, Yakuboff KP and Rothchild D *Development of best evidence statement for the use of pressure therapy for management of hypertrophic scarring.* Journal of Burn Care & Research 2016 37(4):255-264

Staley, MJ and Richard, RL *Use of Pressure to treat hypertrophic burn sc*ars. Advances in Wound Care 1997 10(3) 44-46