Energy Balance Profile in Acute Small-Moderate Burns Patients

Masters of Exercise Science (Research)

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This thesis is submitted as a partial fulfilment of the requirements for the degree of Masters of Exercise Science (Research) at Murdoch University, Perth, Western Australia.

I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary institution.

Mr Tyler Jerome Osborne
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Abstract

**Background:** Burns patients have been shown to exhibit a hyper-metabolic state of activity which can persist for up to two years post-burn. The relationship between total body surface area (TBSA) burned and resting metabolic rate (RMR) has been investigated in larger burns (≥20% TBSA), however not in small-moderate burns (≤15% TBSA). The majority of previous studies have looked at burns ≥ three months after the initial injury. This observational study examined acute effects of small-moderate burns (<15% TBSA) on RMR in burns patients using indirect calorimetry with the secondary aim to investigate the effects of surgery on RMR. Caloric intake was also recorded for comparison to RMR to determine energy balance.

**Methods:** 39 participants (32 male and 7 female) were included in this study via the inpatient burns ward at Fiona Stanley Hospital. Each patient was recruited upon admission to the ward with the day of the initial burn being considered as day 0. Data was collected on day four as able (± one day) and one day prior to and post-surgery as able.

**Results:** The pooled data bivariate correlation showed a significant weak relationship between RMR and TBSA (r=0.435, p=0.009), a significant relationship was also found between RMR and TBSA in males (r=0.634, p=0.001). Patients displayed a positive energy balance of 116kcal/day. The pre and post-surgery RMR data was found to be a non-significant change of -16kcal/day (t=-0.189, p=0.28).

**Conclusion:** This study demonstrated a moderate-strong correlation of RMR and TBSA in males for burns of ≤15% TBSA. The energy balance data showed an average difference of +116kcal/day aligning with the research showing that patients are fed conservatively during a burn injury.
Chapter One: Background

Introduction

Metabolism is the process by which the human body is able to sustain life and optimize function necessary to whatever demands it faces. It occurs via substrates and energy being altered within the body and subsequently exchanged between the internal and external environments [1]. There are multiple components to the assessment of total energy expenditure (TEE) in humans, being the resting metabolic rate, the thermic effect of food and the energy cost of any activity being actively participated in.

The complex nature of a burn injury is characterized by a significant period of hyper-metabolism and catabolism within the body, which are associated with increased morbidity and mortality rates [2]. With major improvements to medical technology, science and hospital resources in recent decades, survivability rates for patients with burns injuries have improved to a point where preventing death is no longer the main outcome, with a universal shift to promoting the best quality of life in burns survivors becoming the primary focus of treatment [3, 4]. The typical responses of burns patients in the acute phase have been extensively researched in larger burns (≥20% total body surface area or TBSA)[2, 3, 5-7], these contribute to the previously described morbidity and mortality through hyper-dynamic circulation, increased body temperature, glycolysis, proteolysis and lipolysis (which lead to extreme substrate usage) [6].

There are many influencing factors that affect the body’s metabolism and thus energy expenditure. These influencing variables include age, gender, dietary intake, injury, exercise and environment [8-10]. When it comes to acute major/severe burns these variables have an equal, if not greater effect, on energy expenditure of the body which is brought about due to increases in heart rate, rates of breathing, body temperature, oxygen consumption, carbon dioxide production as well as glucose, lipid and protein utilization [11]. With these effects to the metabolic state of the body (including substrate usage) nutritional management of burns patients is an important therapy that can be controlled through dietary intake [12].

Some external influencing factors can be controlled by clinicians with regards to energy expenditure in burns patients. The ones that will be considered with the most significance
throughout this paper are dietary intake and environment. The environment of many hospitals with specialist burns wards (such as Fiona Stanley Hospital) often have specifically controlled environments that are tailored for burns patients in terms of temperature, air pressure and infection control.

This literature review will explain the process of metabolism within the human body in the quantitative form of energy expenditure as well the various factors that can influence it, with specific interest in the effects of burns trauma surrounding energy balance. The review will also outline the aetiology, incidence and classifications of burns, before examining the pathophysiology of major/severe burns injuries and their effect on the metabolic rate/energy expenditure and the subsequent changes to dietary intake, as well as the factors that may provide an appropriate means of therapy for negating the changes to acute burn state of energy balance profile.

Burns

Aetiology
Burns represent possibly the widest spectrum of trauma injuries and account for roughly 1% of injuries within Australia [13]. An epidemiological assessment of burn injuries carried out in Western Australia, looked at all burn injury hospital admissions between 1983-2006. The study found that the majority of burns in males occurred at work, via exposure to controlled flames, or the ignition of flammable objects, whereas females occurred mostly at home through scalds as their primary source of burns. While this doesn’t apply to all burns necessarily, it does provide some insight as to how burns occur and what can be expected of patients presenting to burns clinics for therapy.

Classification
Burns can be classified into different degrees based upon both severity and depth [14, 15]. The degrees included in this form of classification are superficial (I), superficial partial (IIa), deep partial (IIb) and full thickness burns (III). Superficial (I) affects the epidermis only, with a moderate to severe pain rating and tend to heal within a time period of under a week [14, 15]. Superficial partial (IIa) involves the superficial layer of the dermis with a severe pain rating and takes up to three weeks to heal [14]. Deep partial burns (IIb) penetrate down to the deeper layer of the dermis and are associated with minimal pain taking up to six weeks to
heal. The last classification of burns are full thickness burns (III), which are characterized by extending into the subcutaneous layer of fat in the skin, or even deeper. There is no pain involved with this type of burn injury due to nerves being damaged at this stage of burning. All of these burns may require a surgical intervention in the form of an excision and skin graft [14, 15].

**Assessment**

One of the most commonly used and accepted forms of estimating percentage of total body surface area (TBSA) is Wallace’s Rule of Nines, which looks at sections of the body (such as the head – front and back, and each arm – front and back, as nine% of the body’s total surface area) as illustrated in Fig 1.

**Figure 1 Wallace Rule of Nines [14]**

![Wallace Rule of Nines](image)

With regards to the TBSA, Miller (2005) et al. found from the National Burn Repository (US data) that 62% of all burns affected less than 10% TBSA [16], this provides reasoning that more research should be investigating the small-moderate burns (<15% TBSA), however most studies within the burns research area are looking at burns greater than 20% TBSA [4]

**Pathophysiology**

The pathophysiology of a burn injury is a complex and traumatic situation for the body that leads to a vastly increased post-burn morbidity rate due to the marked hyper-metabolism and
catabolism associated with major burn injuries, despite the improvements in mortality over the past decades [3]. The primary factors of the metabolic response post burn are catecholamine’s, corticosteroids and inflammatory cytokines [12]. Catecholamine’s are a group of neurotransmitters that affect the function of the sympathetic and central nervous system [17]. While corticosteroids are steroid hormones that regulate carbohydrate metabolism and salt/water balance, and inflammatory cytokines are signalling molecules that promote inflammation [17]. Major burns patients show a 10-20 fold increase in catecholamine’s and corticosteroid levels, which may last up to 12 months post-burn [12]. These hormones are catabolic in nature and prevent the action of insulin and begin the state of increased substrate cycling (lipolysis, proteolysis, gluconeogenesis and energy consumption) [12].

There are two distinct patterns of metabolic activity following a major burn injury [6]. The first phase of this activity occurs within the first 48 hours of injury and is commonly referred to as the ‘ebb’ phase, which is marked by decreases in cardiac output, oxygen consumption, metabolic rate and impaired glucose tolerance (due to a hyper-glycaemic state). These metabolic variables increase within the first five days post-injury to a plateau which is referred to as the ‘flow’ phase, which is associated with a hyper-dynamic circulation and the aforementioned hyper-metabolic variables [6]. Initial research suggested that these alterations in metabolism would resolve with wound closure, however recent studies and improvements in medical technology and research, have indicated that in burns injuries the hyper-metabolism persists post wound closure, and may in fact persist for up to 2-3 years post burn [6, 18].

The hyper-metabolic state post burn consists of a hyper-dynamic response with increased body temperature, oxygen and glucose consumption, CO₂ production, proteolysis, lipolysis and excessive substrate usage [6]. These responses lead to many poor outcomes for the body in the post-burn recovery phase including: loss of lean body mass, loss of bone density, muscle weakness and reduced/poor wound healing. These outcomes are heavily associated with the increased morbidity rate seen in the recovery phase of a major burn injury [3, 7].

The chronic catabolic response of skeletal muscle and the resultant muscle wastage is specifically characteristic of major burn trauma. This loss of lean body mass delays the healing process and contributes to the prolonged long-term morbidity of burns patients [7].
mechanism behind this catabolism is the concurrent increases in skeletal muscle protein synthesis and breakdown rates. However the breakdown rates surpass the synthesis rates, leading to substantial loss of muscle proteins [7]. The significance of lean body mass loss was outlined in terms of mortality with a continuum being present that sees mortality rate increase with the loss of lean body mass [19]. With regards to the energy expenditure of a burns patient, this catabolic response relates directly to the skeletal muscle net balance that arises from the protein catabolism overtaking the rate of protein synthesis in major burn trauma patients [19].

Treatment Options

Surgery
There has been a shift over the past 20 years from prevention of death as the primary focus, to now enhancing quality of life post burn [4]. One of the most commonly utilized treatments is surgical excision/grafting of the burnt site. There is a distinct lack of research in small-moderate burns with regards to surgery, however it has been found that for burns encompassing >50% TBSA, there is a favourable 40% decrease in energy expenditure for patients that are excised and covered within three days of the burn, compared to patients with similar size burns that were excised and covered within a week of the injury [2]. The reason that early surgery is favoured is that it prevents further net loss of protein and skeletal muscle catabolism [20], when comparing early excision (within 72 hours of injury) to late excision (10 to 21 days post burn). It was also found that sepsis rates rose from 20% in the early excision group to 50% in the late group, with the only difference between the groups being the time to excision and grafting. By decreasing the sepsis rate there is a direct effect on the hyper-metabolic response in the post burn recovery, through a decrease in muscle protein catabolism and resting energy expenditure [2].

Nutrition
Nutritional support such as early enteral feeding has been utilized effectively in patients with larger TBSA injuries with positive outcomes, by moderating the extent and degree of the hyper-metabolic response through meeting both the caloric and substrate requirements of a burned patient [12]. The overall goal of nutritional support is to preserve lean body mass in the burned patients, in terms of the caloric requirements this is done through predictive equations (an indirect measure) such as the Harris Benedict method that uses resting
metabolic rate, or the Toronto formula that utilize data collected during hospitalization [21, 22]. While the Toronto formula is an accurate measure that accounts for the excessive energy usage in burns injuries ($r^2=0.67$), it is also complicated to use and administer as it has many variables involved in the equation [23]. Through more research into optimal caloric balance in patients the correct guidelines for nutritional support will be quantified, which will allow for a treatment that provides greater benefit to the patient [12].

Looking specifically at the main substrates utilized during a burn injury (carbohydrates, proteins and fats), these different substrates can provide a variety of positive outcomes within a burn injury [12]. Carbohydrates provide support as a fuel for wound healing and create a protein-sparing effect that decreases the overall loss of lean body mass [12]. The use of proteins throughout nutritional support further increases the protein sparing effect, when carbohydrates are also adequately supplied. Fats also serve a crucial role in the recovery from a burn injury, by preventing the development of essential fatty acid deficiency caused by increased peripheral fat breakdown immediately post-burn [12].

**Exercise**

The previously mentioned forms of therapy have all been related to the acute stages of therapy for a burn injury, but as previously discussed the post-burn physiological response is a sustained insult that can last longer than 12 months [2]. As such patients with burn injury have significant functional limitations throughout this recovery phase, and exercise can be used as an additional treatment option, as it provides increases to lean body mass, strength and overall cardiorespiratory fitness [7, 24]. A systematic review reported an overview on resistance training in burns patients, and found that resistance training was useful in improving physiological function in burns patients, predominantly through muscular strength and lean body mass increases [25]. The study did however mention that further research is necessary to determine specific modalities of exercise, exercise during different periods of the burn phase (acute and sub-acute), as well as looking at small/moderate burns as most studies investigate severe burns [25].

Another review looked at physical exercise from a generalized approach, by outlining the overall effects of exercise on physical fitness for burns patients [26]. It found improvements to muscular strength, endurance, body composition and cardiorespiratory endurance for burns patients. However the study also shared the recommendations of the previously
mentioned review, that during this time of increased attention to physical fitness, that burns research should follow this trend to investigate varying modes, timing and duration and intensities of exercise for a burned population [26].

Energy Expenditure

Metabolic Rate
Basal metabolic rate is the level of energy that is expended when a subject is completely at rest, this usually accounts for 60% of the total daily energy expenditure [9]. The thermic effect of feeding is an increase in TEE associated with the digestion, absorption and storing of food, accounting for roughly 10% of TEE. As not all individuals partake in deliberate exercise the remainder of the daily energy expenditure is made up of non-exercise activity thermogenesis (NEAT) which includes the combined energy cost of daily activities, spontaneous muscle contraction and posture maintenance in most individuals [9].

Assessment
The gold standard of measurement for energy expenditure is through the use of indirect calorimetry [27]. The energy expenditure is quantified by measuring respiratory gases (oxygen consumed and carbon dioxide produced) under specific conditions (usually resting). The most commonly used presentation of energy expenditure in hospital settings is the resting energy expenditure as hospitalized patients are usually bed-ridden. Indirect calorimetry measures the heat energy produced by the oxidation of food substrates, this is done indirectly by assessing the oxygen used and carbon dioxide released according to the patterns and amount of substrate usage [27].

The specific amount of oxygen used is referred to as oxygen consumption (VO$_2$) whereas the carbon dioxide produced is carbon dioxide production (VCO$_2$). The ratio between carbon dioxide and oxygen is referred to as the respiratory quotient, which is denoted by R, and reflects the substrate oxidation in the body (R=1.0 for carbohydrate oxidation, R=0.7 for fats and R=0.8 for proteins), during severe intensity exercise the respiratory quotient can exceed 1.0 [28].
Burns and Energy Expenditure

Previous Research

Previous research into the assessment of energy expenditure through indirect calorimetry has investigated the energy cost and subsequent substrate oxidation of the body under a variety of conditions. In a study of major burn patients looking at the reliability of measuring energy expenditure at rest, it was determined that major burns patients have an energy expenditure of 40-100% above the normal expected levels according to age-predicted REE, across 215 patients from the burns intensive care unit at Hangang Sacred Heart Hospital [29].

Al-Mousawi et al (2010) looked at the energy expenditure of paediatric burns rehabilitation patients, and found that the patients that participated in a 12-week hospital based exercise program (both resistance and aerobic training) had a slight increase in daily energy expenditure (119% of predicted REE) when compared to a standard of care group (109% of predicted REE) [5]. This increase is expected due to the demands of exercise on the body, but importantly it is not a significant increase (p=0.76), as clinician we do not want to further exacerbate the hyper-metabolic response to burn injuries.

Factors Influencing RMR

As previously discussed the energy expenditure is regulated by a number of patient characteristics including caloric intake, as well as other factors specific to a burn injury (location and depth) and forms of trauma [2, 4, 10]. Location of a burn can indirectly influence RMR, such as with inhalation burns, that often accompany facial burns, which lead to acute physiological deterioration due to airway trauma, the depth of a burn relates to how much tissue has been damaged, and the extent of this damage may not become clear until multiple days after surgery [4]. The incorrect removal of tissue may lead to further surgeries, ultimately delaying the recovery process thus increasing the duration of the hyper-metabolic response to major burn injuries.

During the post-burn response the immediate changes to energy expenditure are related to the size and location of the burn, with severe burn injuries exhibiting 140% of predicted resting energy expenditure on admission, which can persist at levels of 110-120% 12 month post burn [2]. The body’s ability to thermo-regulate is affected through a burn injury, with the increase in metabolic rate due to the water and heat loss sustained by burns patients [2]. This
inability to thermo-regulate through sweating and metabolic activity is why hospital burn wards have higher ambient temperatures in an attempt to attenuate the hyper-metabolic activity caused by the thermal aspect of major burn injury [30].

One of the major contributing factors to these changes to energy expenditure is the state of catabolism that the body enters after a major burn injury. This catabolism leads to muscle wasting, which is, the unintentional loss of 5-10% muscle mass that occurs when there is an imbalance of muscle protein synthesis and degradation [31]. This protein degradation can persist for up to nine months post burn, resulting in a significant negative whole body catabolic state, which in paediatric burns ultimately leads to growth retardation for up to 24 months post injury [32, 33]. This muscle wastage is one of the influential factors that we as clinicians will be able to minimise through a better understanding of both the hypermetabolic response of a burn injury as well as the nutritional support required to supplement the substrate usage (specifically proteolysis). These factors have been investigated in major burn injuries (≥20% TBSA), with no research reporting the influence of these factors on small-moderate burn injuries.

Caloric Intake
Dietary intake is an influencing factor of energy expenditure that can be utilized by clinicians to negate the hypermetabolic state during a burn injury [2]. The dietary intake should match the energy expenditure of the body, this is known as energy balance and refers to the difference between calories coming into the body, and the calories you burn each day [34]. By having a clear understanding of the metabolic state of the body during a burn injury, nutrition can be altered to provide appropriate caloric levels and higher levels of fat, protein or carbs to supplement the appropriate substrate usage taking place at various time points in the acute post-burn stages [2].

With the excessive energy expenditure in burned patients, it is necessary to adjust the energy intake (caloric intake) to match the increased energy cost, in order to minimize the combined effects of the hypermetabolic and catabolic processes of a burn injury. Research has shown that through aggressive nutrition in the form of 25kcal/kg body weight and 40kcal per percent TBSA burn per day, that body weight can be maintained in burned adults by mitigating the degree and extent of the persistent hyper-metabolic response seen in major burn injuries [35,
It was also mentioned that appropriate nutrients can be delivered to burned patients by feeding 1.2-1.4 times the energy expenditure as measured via indirect calorimetry, however the previous method has shown more consistent results of maintaining body weight in burned adults [37].

**Conclusion**

The body’s response to a burn injury is both hypermetabolic and catabolic in nature, and can persist for an extended period of time. Even with the majority of research focusing on burns >30% TBSA, small-moderate burns (<15% TBSA) can have lasting effects on the body long after the wound has healed [3, 6]. With the increased effect on energy expenditure persisting for up to 1-2 years post burn, the long term management of the hypermetabolic and catabolic effects on the body, is of the utmost importance [2]. By developing the knowledge base around small-moderate burn injuries, this study will be able to help guide the clinical interventions used for patients with small-moderate burns. This is where nutritional management, in the form of caloric intake being changed to match the energy expenditure (RMR) of burned patients, as well as meeting the requirements of the substrates that are excessively utilized post burn, can be an effective long-term management option. The use of nutritional management throughout the post burn recovery phase is a strong example of the universal shift of clinical goals regarding burns injuries to provide the best survivability and quality of life post-burn [4].
Chapter Two: Study Purpose, Research Aims and Hypotheses

Statement of the Problem

The interaction between energy expenditure and burn injuries has been researched in burns encompassing ≥20% TBSA. A heightened metabolic activity has been demonstrated to persist in the post-burn injury phase for up to two years post-injury. What is not well understood, is the relationship between energy expenditure and TBSA in smaller burns (≤15% TBSA). The relationship is often assumed from research in larger burns [3, 4, 6, 16] however this has not been investigated. There is a clear lack of research for small-moderate burns (≤15% TBSA) and their relationship with energy expenditure, despite the findings of Miller et al. from the National Burns Repository, reporting that as many as 62% of all burns affect ≤10% TBSA [16], therefore the energy requirements of the majority of burns patient is not well understood.

With the lack of research into the relationship between energy expenditure and burn size, there is limited research investigating the effects of interventions such as surgery and nutrition for these smaller burns, despite there being a sizeable amount of literature on these interventions for larger burn injuries [2, 12]. In smaller burns the use of surgery in the form of an excision and skin graft (the removal of dead, necrotic tissue that is replaced with a graft from an appropriate site on the body) has been found to be a successful method in terms of reducing post-operative complications [38], but the effects of surgery on energy expenditure has not been investigated, despite the fact that surgery introduces further trauma to the body, potentially cascading the hyper-metabolic changes seen in burn injuries.

The nutrition of small-moderate burn patients is not well understood, however the effects of the main substrates utilized in a burn injury have been outlined. Fats prevent the development of essential fatty acid deficiency due to the increase peripheral fat breakdown. Carbohydrates provide a fuel for wound healing, and create a protein-sparing effect to minimise lean body mass loss and proteins increase the overall sparing effect, when adequate levels of carbohydrates are also provided. Another important area of nutrition within burns is the caloric intake that patients receive, as the body is burning more energy it is important to match the excess energy expenditure to the intake of energy (this is referred to as energy balance) to minimise the loss of lean body mass commonly occurring as a result of a burn injury.
Through investigation of the relationship between energy expenditure and burn size in small-moderate burns (≤15% TBSA) there is opportunity to improve the current clinical guidelines for treatment through a developed understanding of the acute physiological response to a small-moderate burn injury, rather than assuming the relationship that exists for larger burns applies to smaller burn injuries.

Research Aims

1. Investigate the relationship between TBSA burnt and resting energy expenditure in burns of <15% TBSA.

2. Examine any changes to resting energy expenditure that occur in response to surgical intervention.

3. Examine the current caloric intake of burned patients, and whether this matches their energy expenditure (energy balance).

Hypotheses

1. The relationship between TBSA and RMR will follow a linear trend for burns of <15% TBSA, as suggested in larger burns.

2. Energy expenditure will increase after surgery in burned patients.

3. Caloric intake will not currently adequately match energy expenditure of burned patients.

Significance of Study

Through the investigation of the relationship between energy expenditure and burn size in small-moderate burns (≤15% TBSA), we are able to further the current understanding of the acute hyper-metabolic response that occurs post-burn injury. By developing the current knowledge base on how metabolism reacts with small-moderate burns, we may help guide clinical interventions in the form of nutritional intake and surgery during patient’s hospital stays. Having the ability to match caloric intake to the energy expenditure of patients will help to minimize the loss of lean body mass that is often seen in the persistent chronic hypermetabolic state in burn injuries [7, 19]. As surgery introduces trauma to the body, it is
expected to induce a hyper-metabolic response, so further understanding of how surgery plays a role in the acute metabolic response in a burn injury will aid in filling the distinct lack of research that exists for small-moderate burns. Therefore, this study will help to develop a better understanding of the nature of a small-moderate burn injury throughout the acute phase of recovery. This information will allow for future studies to investigate the effects of different nutritional interventions and the use of exercise as an intervention for small-moderate burn-injuries. As there are serious consequences in terms of morbidity and mortality associated with burn injuries, it is important we add to the literature for small-moderate burns in order to optimize treatment options available to patient’s during their hospital stay in the acute post-burn injury phase.
Chapter Three: Manuscript

The following chapter has been formatted for submission to the Burns Journal of the International Society for Burns Injuries. As such, all sections have been prepared in accordance with the journal’s author’s guidelines (Appendix I). One notable exception to the required guidelines set out in the author’s guidelines is the embedding of tables and graphs within the article text, rather than their attachment in a separate document.
Energy Balance Profile in Acute Burns Patients

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Abstract

**Background:** Burns patients have been shown to exhibit a hyper-metabolic state of activity which can persist for up to two years post-burn. The relationship between total body surface area (TBSA) and resting metabolic rate (RMR) has been investigated in larger burns (≥20% TBSA), however not in small-moderate burns (≤15% TBSA). The majority of previous studies have looked at burns ≥ three months after the initial injury. This observational study examined acute effects of small-moderate burns (<15% TBSA) on RMR in burns patients using indirect calorimetry with the secondary aim to investigate the effects of surgery on RMR. Caloric intake was also recorded for comparison to RMR to determine energy balance.

**Methods:** 39 participants (32 male and seven female) were included in this study via the inpatient burns ward at Fiona Stanley Hospital. Each patient was recruited upon admission to the ward with the day of the initial burn being considered as day zero. Data was collected on day four (± one day) and one day prior to and post-surgery as able.

**Results:** The pooled data bivariate correlation showed a significant weak relationship between RMR and TBSA ($r=0.435$, $p=0.009$), a significant relationship was also found between RMR and TBSA in males ($r=0.634$, $p=0.001$). Patients displayed a positive energy balance of $116\text{kcal/day}$. The pre and post-surgery RMR data was found to be a non-significant change of $-16\text{kcal/day}$ ($t=-0.189$, $p=0.28$).

**Conclusion:** This study demonstrated a moderate-strong correlation of RMR and TBSA in males for burns of ≤15% TBSA. The energy balance data showed an average difference of $+116\text{kcal/day}$ aligning with the research showing that patients are fed conservatively during a burn injury.

**Keywords:** Energy Balance, Resting metabolic rate, small-moderate burn injuries

**Highlights:**

- Small burns exhibit similar changes to resting metabolic rate seen in larger burns
- Caloric intake requires further research to optimize feeding for burn patients
- Surgery has a minimal effect on the metabolic rate of burn patients
Introduction

Burns are a complex injury caused by exposure to heat, chemicals, electricity or sunlight that affects the skin and deeper associated tissue [14]. The physiological response to a burn injury occurs across two phases that represent a shift in metabolic activity. The first phase is referred to as the ‘ebb’ phase, occurs within 48 hours of the initial injury, and is characterized by decreased circulation (cardiac output and oxygen consumption) and subsequently resting metabolic rate (RMR) [6]. This is referred to as a hypo-metabolic response. These physiological responses have only been observed in major burns, and gradually increase over the first 4-5 days post injury before achieving a plateau in a hyper-metabolic state, referred to as the ‘flow’ phase [6].

The research into the interaction between surgery and expenditure for smaller burns is an area that is lacking, despite Miller et al. reports from the National Burns Repository that as many as 62% of burns effect <10% total body surface area (TBSA)[16]. The relationship between energy expenditure and major burns (>50% TBSA) found that there was a 40% decrease in energy expenditure for patients that are excised and covered within 3 days of the injury, compared to similar size burns that were excised within a week of injury [2]. This relationship has been assumed in smaller area burns but has yet to be comprehensively investigated.

Nutrition is a key component of treatment for burns patients, as with changing metabolic activity, the nutritional requirements of the body also change [12]. The objective of nutritional support is to minimize lean body mass loss during the acute post-burn phase, by matching the caloric requirements of the patient, as determined by their RMR [12]. Matching the caloric intake to the energy consumed by the body daily is referred to as energy balance, and despite conservative approaches to feeding, it would be ideal for the intake to match the energy expenditure to minimize further loss of muscle mass during the patients with burn injuries hospital stay [7, 12, 39].

Conversely clinicians are trying to avoid overfeeding burned patients which can lead to increases in fat mass deposits and adverse events post burn, as such a neutral balance of intake to expenditure is optimal for clinicians [12]. As previously stated RMR for small-moderate burns has not been researched despite making up the majority of burns [4, 12],
further understanding of RMR and thus energy balance, will help to improve current clinical guidelines for burns patients [12].

Another area not well understood in small-moderate burns is the effect of different moderating variables on resting metabolic rate [8], including but not limited to; age, gender, body mass index (BMI), body temperature, grip strength (as an overall marker of strength) and heart rate. There is evidence demonstrating these variables have some level of influence on RMR, either independently or in larger burns, but the complexity of the effect and interactions between influencers on small-moderate burns is not well understood [8]. Johnstone et al (2005) investigated the effect of age and body composition on RMR in the healthy adult population, and found fat free mass explained 63% of variation, six % was explained by fat mass and two % from age, however it was also stated that morphological characteristics alone cannot explain the between-individual characteristics in RMR, and physiological effects must also be examined [8].

With a burn injury comes an increased energy demand brought about by the inflammatory response and hyper-dynamic circulation, as the body utilises anabolic and catabolic reactions to promote wound healing [1, 40], through early wound coverage via surgery it may be possible to reduce the energy demands on the body by facilitating the wound healing process [7, 20]. A common intervention used to attenuate this physiological response to burn injuries is excision/graft of the burn site [20, 41]. This procedure sees necrotic and inflamed tissue excised from the body and replaced with a skin graft taken from an appropriate site on the body [20, 41]. Both burn injuries and surgery introduce trauma to the body, but post-burn injury surgery is an essential part of treatment for wound healing and recovery, and its use in small-moderate burns has been found to be both safe and feasible [38]. As such, burns patients who undergo surgery, may exhibit further increases in metabolic activity [6, 7].

The majority of research pertaining to burns and their effects on metabolism has been conducted in large burns (>20%) with relationships for small-moderate burns, for the most part assumed based on trends seen in these larger burns [3]. As such there exists a gap in the literature for small-moderate burns, despite the vast majority of burns falling into this category [4]. Therefore, this study aimed to 1) investigate small-moderate burns and changes to metabolism seen at day four (± one day) post-burn, 2) investigate changes to metabolism associated with surgery after a burn injury, 3) examine the energy balance of burns patients,
4) investigate the effects of any potential moderating variables on RMR variations in the acute post-burn phase.

Methods

Design
This observational study followed a prospective cohort design. All participants were measured for RMR on the fourth day post burn (± one day) as the primary measure of the study, regardless of whether they had surgery prior to baseline testing. Secondary measures of caloric intake and moderating variables were recorded in tandem. In addition, for patients undergoing surgery, RMR assessments were carried out one day before and one day after surgery (± one day). The one-day window either side of the measures was necessary due to the rapidly changing dynamic of the hospital environment. The day the injury occurred was designated as day zero. This time frame was selected due to the metabolic plateau occurring approximately four days post-burn, signifying the ceiling of the hyper-metabolic state [6].

Upon admission to the ward, patients were provided with an information letter explaining the study, and after any queries had been answered, informed consent was signed. Resting metabolic rate was collected between 06:00 and 08:00 within the acute burn unit, as this time period fell between the morning round of medication and the serving of breakfast, minimising the impact the testing period had on patients while still meeting the criteria for gathering of metabolic data [42].

Participants
Recruitment took place over a five-month period (May-September 2019). Patients were recruited as soon as possible after admission, which ranged from one to seven days post-burn. The recruitment of patients took place over a five-month period. The inclusion criteria for participation were; patients >18 years, presenting to the inpatient ward of the burns ward with burns ≤15% TBSA acquired within the last seven days, and spontaneously breathing (for the requirements of RMR testing). Exclusion criteria included; burns to the mouth that would affect the ability to form a seal around the mouthpiece for RMR testing, and electrical and inhalation burns due to the difficulty in determining TBSA burnt in these types of injuries. This study and its methods were approved by both the Murdoch University Human Research Ethics
Committee (Project Number 2016/228) and the South Metropolitan Health Service Human Research Ethics Committee (PRN: RGS000000013) prior to commencement.

Anthropometric Measures
Descriptive data including age, sex, height and body mass were collected at baseline via patient recall (body mass was taken from hospital observation charts on the day of each testing session) (Table 1). Burn size was assessed as TBSA, using a combination of the Rule of Nines and the Rule of Palms, which have designated percentages for certain sections of the body, or in the latter method approximately one percent TBSA being the same size as the patient’s palm [43]. TBSA was assessed upon admission by the nursing staff and again during surgery by the operating surgeon.

Physiological Measures
Metabolic data, in the form of RMR, was collected via indirect calorimetry to calculate metabolic rate and substrate oxidation via measurement of gas exchange at rest (Quark RMR, COSMED, Italy) [39]. This method is considered the gold standard measurement for energy expenditure [42]. The measurement was taken with the patient in a supine position, in a dimly lit and quiet room. Testing took place at least two hours after any wound dressing or other pain inducing procedure, at least four hours of fasting, and 12 hours after any form of vigorous activity.

The snorkel-like mouthpiece was used so that patients with facial burns could be included, so long as they could form a seal around the mouthpiece for the duration of the testing. Gas exchange was collected for 5 minutes after a steady state had been achieved to allow for minimal intrusion on the patient. RMR was calculated from the gas exchange data via the use of the modified Weir formula [44].

\[
24\text{-hour resting energy expenditure} = 1.44 \left[ (3.94 \times VO_2) + (1.11 \times VCO_2) \right]
\]

\[VO_2 = Volume \ of \ oxygen, \ VCO_2 = Volume \ of \ carbon \ dioxide\]

Nutritional Measures
Dietary intake was recorded via a standard hospital dietary intake form, as well as the percentage of the meal eaten to determine caloric intake over a 24-hour period before RMR testing, this included any protein supplements the patients may have consumed before
Hospital prescribed gym sessions. The dietary information was interpreted as calories consumed using the Foodworks dietary analysis program (Version 10; Xyris, Australia). Each patient’s appetite was recorded after lunch the day before RMR testing (as per caloric intake) using appetite-specific visual analogue scales (VAS). These scales asked patients to separately rate their sensations of hunger, fullness, desire to eat and quantity the patient could eat. Each scale was a 100mm line, where the patient would mark with a pen between 0-100, with descriptors defining each end of the scale (not hungry at all, or as hungry as I have ever been). Patients with hand burns were able to point to the position on each scale that they wished to score themselves, if they were unable to grip the pen.

Grip Strength
To assess strength, we used an analogue handheld dynamometer (Sammons Preston Rolyan, Bolingbrook, Illinois, USA). Patients were seated on the side of their bed, with their elbow flexed at 90 degrees [45]. Using their dominant hand first, the patient closed their grip on the handle as hard as possible for 3 seconds to register their best possible score, this was then repeated on the non-dominant hand. This procedure was repeated three times with the best score from each hand being used.

Physical Activity and Medical History
To determine each patient’s recent exercise history, the international physical activity questionnaire (IPAQ) short from was used to quantify physical activity levels in the last 7 days before being admitted to hospital [46]. The data from this questionnaire represented a MET score for each patient and was assessed as a predictor for any variations in RMR. Medical history in the form of surgical intervention was recorded to identify patients suitable for the secondary measure of surgical effects on RMR. Body temperature and heart rate were collected prior to baseline (day four) RMR testing as both can exhibit changes throughout the post-burn recovery. Both measures were taken from observation charts filled in by nursing staff, the measurements were taken immediately prior to RMR testing. These measures were also analysed as predictors for potential observable variations to RMR.

Statistical Analysis
Data within this study was not assessed for normality. There was no power calculation used as this was a sample of convenience for an observational study. Data collected was analysed using Statistical Package for the Social Sciences Statistics (version 26; IBM corp., Somers, NY,
USA), significance was set at \( p \leq 0.05 \). Within the analyses for this study, data is presented as a combined group and then by gender group due to the differences seen in energy expenditure between males and females. These differences are largely centred on lean body mass which is seen to be greater in men, even when compared to relative body mass [47, 48].

Pearson’s product moment correlations were used to examine the strength of any relationship between TBSA and RMR, as well as any existing relationship between substrate oxidation (fats and carbohydrates) both TBSA and RMR. The interactions between TBSA, appetite and energy intake were also analysed using Pearson’s product moment correlations. Energy balance was determined as the difference between calories consumed 24 hours prior to RMR collection (from dietary intake records) and the calories utilised (energy expenditure). Paired sample t-tests were used to determine if energy expenditure was different between pre- and post-surgery time points. For the moderating variables a forward stepwise linear regression was used, which starts with a general model and sequentially adds variables to determine if significance has been reduced, as variables become non-significant they are removed from the model. This was used to determine any effects of moderating variables including age, sex, BMI, grip strength, caloric intake, appetite scores, body temperature, heart rate and exercise history on variation in RMR. Descriptive statistics were preferentially presented as Mean and Standard Deviation, but for skewed data Median and Interquartile range was used. An independent t-test was used to examine the differences between the male and female groups for their respective physical activity levels measured by their IPAQ score.

Results

Participant Characteristics

A total of 112 patients were screened for eligibility, with 45 patients (35 male, 10 female) recruited to the study (Figure 1). Reasons for exclusion included; missed testing period, not interested in the study, facial burns (being unable to form a seal around the mouthpiece) and early discharge. After recruitment to the study, 6 patients had no data collected (3 patients were moved from the ward before testing, and 3 chose to withdraw on the morning of testing), leaving 39 patients (32 male, 7 female) for participation in the study. Given the small sample of female participants, we were unable to perform subgroup analysis on females only.
Males appeared to have a higher mean physical activity level (7435.2 ± 6783.1 MET-min/week) compared to females (1727 ± 3135.8 MET-min/week) (p=0.008) within this study, consistent with previous research into gender differences in physical activity [48] (Table 2).

**Table 1 Descriptive Characteristics for 45 Participants**

<table>
<thead>
<tr>
<th></th>
<th>Combined (n=45)</th>
<th>Male (n=35)</th>
<th>Female (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>43 ± 20 (19-85)</td>
<td>42 ± 18 (19-85)</td>
<td>46 ± 24 (19-84)</td>
</tr>
<tr>
<td>TBSA (%)</td>
<td>3.7 ± 3.3 (0.2-15.0)</td>
<td>3.2 ± 2.7 (0.2-11.0)</td>
<td>5.2 ± 4.7 (1-15.0)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.73 ± 0.11 (1.52-1.95)</td>
<td>1.78 ± 0.07 (1.65-1.95)</td>
<td>1.59 ± 0.05 (1.52-1.65)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>79.0 ± 19.2 (54-133)</td>
<td>89.2 ± 17.7 (56-133)</td>
<td>64.4 ± 9.2 (54-83)</td>
</tr>
<tr>
<td>BMI</td>
<td>24.0 ± 5.2 (18.9-42.9)</td>
<td>28.2 ± 5.4 (18.9-42.9)</td>
<td>25.6 ± 4.7 (19.8-34.4)</td>
</tr>
</tbody>
</table>

Data presented as Mean ± Standard deviation (range).

**Table 2 Baseline Patient History Characteristics for 45 Participants (35 male, 10 female)**

<table>
<thead>
<tr>
<th></th>
<th>Combined</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPAQ (MET-mins/week)</td>
<td>3519 (660-9495)</td>
<td>6852 (1572-12105)</td>
<td>561 (82-1372)</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>68 ± 11 (50-90)</td>
<td>67 ± 12 (50-90)</td>
<td>71 ± 9 (60-80)</td>
</tr>
<tr>
<td>Body temperature (°)</td>
<td>36.5 ± 0.2 (36.2-36.9)</td>
<td>36.5 ± 0.2 (36.2-36.8)</td>
<td>36.6 ± 0.2 (36.3-36.9)</td>
</tr>
</tbody>
</table>

IPAQ data presented as Median (IQR), Heart rate and Body temperature presented as Mean ± Standard Deviation (Range)
Figure 2 Participant Flow Diagram for Eligibility within the Study

Screened for study eligibility (n=112)

Excluded (n=67)
- Missed testing (n=22)
- Not interested (n=15)
- Facial burns (n=9)
- Early discharge (n=8)
- TBSA >15% (n=6)
- Other (n= 7)

Recruited to study (n=45)

Not able to collect data (n=6)
- Patients moved from ward on day of testing (n=3)
- Withdrew on morning of testing (n=3)

Analysed (n=39)
Influence of TBSA Burnt on RMR

Baseline RMR for the participants had a mean value of 2157 kcal·day⁻¹. The bivariate correlation between these two variables was shown to be positive, however this correlation was found to be significant with a weak-moderate positive relationship ($r=0.435$, $p=0.009$, $n=35$) (Fig 2).

**Figure 3** Baseline Resting Metabolic Rate (RMR) and Total Body Surface Area (TBSA) correlations for combined 35 participants

In a subsequent sub-group analysis, RMR for males had a mean of 2360 kcal·day⁻¹. The bivariate correlation was indicative of a significant moderate-strong positive relationship of $r=0.634$, $p=0.001$. 
Figure 4 Baseline Resting Metabolic Rate (RMR) and Total Body Surface Area (TBSA) correlations for 26 males

Table 3 Measured RMR and Predicted RMR Comparison

<table>
<thead>
<tr>
<th></th>
<th>Combined</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Predicted RMR</td>
<td>151 ± 48 (99-250)</td>
<td>158 ± 53 (102-250)</td>
<td>132 ± 27 (99-167)</td>
</tr>
</tbody>
</table>

Data presented as Mean ± Standard Deviation (Range)

Associations of Moderating Variables on Variations in RMR

From a selection of variables, height was found to be the most influential moderator (r=0.481) of RMR. (6 males had no moderating variables recorded). The strongest moderator was age (r=0.614), although there were not enough female participants available for the forward stepwise model to be used.
Table 4 Regression Scores for Moderating Variables for RMR

<table>
<thead>
<tr>
<th>Variables</th>
<th>Combined</th>
<th>P value</th>
<th>Male</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>0.481*</td>
<td>0.02</td>
<td>0.058</td>
<td>0.790</td>
</tr>
<tr>
<td>Gender</td>
<td>0.265</td>
<td>0.423</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Age</td>
<td>-0.434*</td>
<td>0.019</td>
<td>0.614*</td>
<td>0.09</td>
</tr>
<tr>
<td>Weight</td>
<td>0.013</td>
<td>0.957</td>
<td>0.234</td>
<td>0.302</td>
</tr>
<tr>
<td>MET score</td>
<td>-0.026</td>
<td>0.900</td>
<td>-0.242</td>
<td>0.254</td>
</tr>
<tr>
<td>Appetite</td>
<td>0.003</td>
<td>0.988</td>
<td>-0.063</td>
<td>0.777</td>
</tr>
<tr>
<td>Body temperature</td>
<td>-0.022</td>
<td>0.911</td>
<td>0.035</td>
<td>0.870</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>0.194</td>
<td>0.328</td>
<td>0.399*</td>
<td>0.049</td>
</tr>
<tr>
<td>Handgrip Strength</td>
<td>0.223</td>
<td>0.208</td>
<td>-0.274</td>
<td>0.293</td>
</tr>
</tbody>
</table>

Significant Variables denoted by *

Energy Balance of Burned Patients

Energy balance data of 26 patients (19 male, 7 females) (7 male patients had no baseline RMR collected, while another 6 males had no caloric intake data recorded) is shown below (Figure 5). The difference between intake and expenditure for males and females combined was non-significant at -116 kcal·day⁻¹ (p=0.23) ranging from -1188 to +1757 kcal·day⁻¹. For males the difference was -257.31 kcal·day⁻¹ (p=0.11).
Appetite, Intake and TBSA relationships
There was no significant relationship between reported appetite and TBSA for the combined data \((r=0.1418, p=0.4896, n=26)\), or for males only \((r=0.0229, p=0.926, n=19)\). In this study cohort, there was also no relationship evident between energy intake and TBSA for the combined data \((r=-0.1088, p=0.569, n=30)\), and males only \((r=-0.1497, p=0.487, n=24)\). Finally, there was no relationship between appetite and energy intake for combined \((r=-0.034, p=0.876, n=24)\) and male data \((r=-0.114, p=0.656, n=18)\).

Effects of Burn Size and RMR on Substrate Oxidation
Substrate oxidation was analysed for fat and carbohydrate oxidation; the collective group utilized an average of 736 kcal·day\(^{-1}\) of fat and 1367 kcal·day\(^{-1}\) of carbohydrates, the males utilized an average of 674 kcal·day\(^{-1}\) of fat and 1594 kcal·day\(^{-1}\) of carbohydrates.

In the collective group there was no significant relationship between TBSA and fat \((r=0.08, p=0.682, n=26)\) or carbohydrate oxidation \((r=0.03, p=0.884, n=26)\). The RMR and fat oxidation were also not related \((r=-0.08, p=0.714, n=26)\), although RMR and carbohydrate oxidation demonstrated a moderate-strong correlation \((r=0.70, p=0.001, n=26)\).

For males, there was no significant relationship between TBSA and fat \((r=-0.0004, p=0.987, n=19)\) or carbohydrate oxidation \((r=0.44, p=0.068, n=19)\). The RMR and fat oxidation also
were not related ($r=0.03$, $p=0.911$, $n=19$), although RMR and carbohydrate oxidation showed a moderate-strong correlation ($r=0.6206$, $p=0.013$, $n=19$).

Effects of Surgical Intervention on RMR

Ten patients (six males, four females) recruited for this study had pre and post-surgical data collected. The differences in RMR observed in patient’s both pre and post-surgery (Figure 4) The paired sample t-test showed no significant differences for any group, the collective group had a difference between pre and post-surgery of -16 kcal·day$^{-1}$. The male analysis showed a mean difference of -68.1 kcal·day$^{-1}$. Female analysis showed a mean difference of +64.3 kcal·day$^{-1}$.

![Figure 6](image)

**Figure 6** Pre and Post-Surgery Resting Metabolic Rate (RMR) Data for 10 participants (6 males, 4 females)

Discussion

The key findings from this study were 1) the linear relationship between TBSA and resting energy expenditure reported in larger burns ($\geq 20\%$) [3, 4, 6, 18] is also apparent in small-moderate burns for males (Figure 3) 2) Surgery had no influence on RMR 3) Caloric intake is on average 116 kcal/day less than expended energy in burns patients, non-significant but aligning with suggested ‘conservative’ feeding strategy previously reported in this population.
4) Moderating variables showed minimal influence on observable variations in RMR and
5) there is a moderate-strong correlation between carbohydrate oxidation and RMR.

Previous research in larger burns have reported RMR is often 120-140% of non-burn predicted
RMR [2-4, 6, 18], the findings from our study in small-moderate burns reflected similar
changes to RMR seen in major burns, with the combined group reporting a measured RMR
that was average 154% of non-burn predicted RMR, while males had an average of 158% and
females showed 132%. The hyper-dynamic response that causes this change includes
increased body temperature, increased oxygen and glucose consumption, and excessive
substrate usage [3, 6]. Our current study demonstrates a moderate-strong correlation
between TBSA and RMR (r=0.63, p=0.001) in male burns patients (seen in Figure 3). Larger
burns result in a greater rate of energy expenditure in the acute stages of recovery, however
this positive linear trend has previously only been assumed in small-moderate burns. We have
demonstrated this trend does in fact occur in males with small-moderate burns. This was
expected to be the case for smaller burns (≤15%) due to the hypermetabolic nature of burn
injuries [6, 18] however no other study to date has reported this finding.

There was a moderate relationship between TBSA and RMR (r=0.435, p=0.009) for males and
females combined (seen in Figure 2). While this correlation is not as strong as for the male
only group, this can likely be attributed to gender related differences observed in resting
energy expenditure, where females demonstrate a decline in RMR seven years earlier than
their male counterparts (29 years old vs 36 years old) [47, 49]. Geisler et al (2015) found in
healthy populations, while females begin their decline in RMR earlier than males, this decline
also occurs at a greater rate per decade (470kj/day for female’s vs 310kj/day for males) [47].
This is likely due to changes in organs and tissues associated with ageing, however female
specific changes are also likely seen during menopause [50]. Gender differences for RMR have
not been investigated in small-moderate burns and while the lack of female participants did
not allow us to determine female specific differences, analysing RMR and TBSA relationship
in males only we were able to provide a clearer understanding of the interactions between
TBSA and RMR in small-moderate burns. The ratio of males to females in this study is in
keeping with epidemiological burns data (32 males and seven females) that suggests females
make up 24% of all burns cases in Western Australia [51].
There are multiple factors that can influence resting energy expenditure, in healthy populations these variations are driven by lean mass, height weight and age, and as such we investigated the effects of various moderating variables on RMR, to understand the mechanism behind why variations in RMR data of burns patients occur (Table 3). In keeping with previous research in healthy populations, which sees changes in RMR predominantly driven by lean mass, height and weight, our findings demonstrate height had the strongest moderating variable on RMR [52]. Gender, heart rate and grip strength also showed plausible positive association with RMR variation, while age had a moderate negative effect. These findings are consistent with research into moderating variables of basal metabolic rate of healthy populations, showing that morphological characteristics (height, weight, muscle mass) largely explain the variation seen in RMR. Johnson et al (2005) [8] suggests non-morphological characteristics (such as heart rate and grip strength) should also be examined for their effects on RMR, this is of particular importance for burns patients, as an increases in heart rate as a result of hyper-dynamic circulation and catabolic effects on muscle strength are a common response to burn injury [8, 47, 49], and if these changes are affecting variation in RMR, clinicians need to be aware of the changes that are occurring.

Age exhibited the greatest influence on RMR in males, which would be expected due to changes seen in male RMR levels around the age of 37 [47], in line with our reported patient demographics (42 ± 18 years old) with a split of patients above and below the age of 37 [47]. Physical activity (METs) and grip strength also showed a weak negative effect, possibly due to the high reported physical activity levels in this study compared to other research into older age groups (3519 MET-min/week vs 2106 MET-min/week [33-88 years][53]).

In order to compensate for the increased metabolic activity seen in the acute recovery phase, caloric intake should ideally match the energy expenditure of burns patients [12]. Participants consumed 116 kcal·day⁻¹ less than their calculated energy expenditure (in Figure 4), determined via indirect calorimetry. While this difference is plausible a larger sample size is required to confirm if this is a significant difference, a calculation of the effect size showed a small effect size (Cohen’s d=0.23). In males, we found they consumed 257 kcal·day⁻¹ less than their calculated energy expenditure, again while this difference may be clinically meaningful, a larger sample size is need to confirm whether this is significant (Cohen’s d=0.11). A caloric deficit in burns patients can lead to additional loss of lean body mass, which is linked with
increased levels of mortality [19]. Therefore this loss of lean body mass should be avoided where possible. This finding, although non-significant, reflects the current research in larger burns that reports a ‘conservative’ approach to feeding being undertaken. In paediatric burns an adjustment factor of 1.4 has been recommended to meet the energy demands of patients and maintain body weight, so it is likely that a similar adjustment factor is required in an adult burn population [12, 54].

As the body recovers from a burn injury, the increased energy demand is reflected in an increased level of fats, proteins and carbohydrates being utilized [12]. The oxidation of fats and carbohydrates has not been previously reported in burns patients to our knowledge. Given the role of carbohydrates (wound healing and protein sparing) and fats [12] (preventing the development of essential fatty acid deficiency) in the post-burn recovery phase we investigated the effects of RMR and TBSA on substrate oxidation [12, 31]. Carbohydrate oxidation showed a moderate-strong relationship RMR. This was expected due to the role of carbohydrate in promoting wound healing and protein sparing during recovery from burns [12]. Protein breakdown is expected in burns patients (as high as 150% above normal levels) due to the catabolic reactions needed for wound healing and recovery post injury. This protein breakdown rate can exceed 150g/day, however when carbohydrates are adequately supplied proteins are spared leading to a reduction in the loss of lean body mass [12]. There was no relationship present for TBSA, RMR and fat oxidation or for carbohydrates and TBSA.

As surgery promotes wound closure after surgery, the metabolic activity is hypothesised to decrease after surgical intervention[4]. To develop the understanding of how surgery interacts with RMR we investigated the effects of surgery on RMR. Ten participants had pre and post-surgical data and exhibited a reduction in RMR of 16kcal/day (p=0.42) following surgery. This difference is consistent with research suggesting that wound closure via surgery doesn’t affect the long-term persistent effect of a burn injury on energy expenditure [18]. It has been reported that inflammatory markers don’t markedly change from admission to post-surgery, which were previously understood to reduce greatly after wound coverage [18, 55], however after surgery it may be expected that energy expenditure would increase due to the additional trauma [6, 7, 56]. The trauma induced by surgery is referred to as the surgery stress response that produces a systemic response of increased metabolic and hormonal activity which evokes a similar, yet weaker response to a burn injury [57].
While this study has taken a unique approach to characterising the metabolic consequences of small-moderate burns, there were limitations. Due to the dynamic nature of the patient recruitment during the data collection period, it was difficult for patients to present prior to and post-surgery for RMR assessment, and as such there was a lack of for pre- and post-surgical data available. Subgroup analysis was not feasible with females in this study, limiting factors of this were the time available for recruitment and the previously mentioned difficulties with patient recruitment due to the dynamic nature of the hospital environment.

In conclusion, this study demonstrated a relationship between RMR and TBSA similar to that which has been described in larger burns (≥20%) [3, 4, 6, 18, 56]. A plausible weak negative association was seen in RMR after surgery for burned patients [18, 55]. In the male-only sub-analysis, similar findings of a moderate-strong linear relationship between TBSA and RMR was demonstrated, as well as a plausible weak negative association in RMR after surgery. While a non-significant negative energy balance of -116kcal/day was found during the acute phase of recovery, from a clinical perspective we suggest from our findings in the male sub-group that nutritional prescription may need to be refined to match the expended levels of energy in an attempt to optimize patient treatment.

Small-moderate burns account for as much as 62% of all burns cases [4], therefore further investigation of the effects these burns have on metabolic activity, as well as the common methods of treatment including surgery and nutrition will develop this understanding further and continue to promote updated clinical guidelines to provide patients with the best outcomes of survivability and quality of life post-burn. Future research should examine not only the effects, but the mechanisms behind the hyper-metabolism associated with burns, to gain further insight into approaches which can improve the standard of care via minimizing the hyper-metabolism that patients will endure in the post-burn recovery phase.

Conflict of Interest
The authors declare that there is no conflict of interest.

Acknowledgements
The authors would like to thank Dr. Fiona Wood and the staff at the State Adult Burns Service for their work and help with the study.
References


8. Johnstone AM, Murison SD, Duncan JS, Rance KA, Speakman JR. Factors influencing variation in basal metabolic rate include fat-free mass, fat mass, age, and circulating thyroxine but not sex, circulating leptin, or triiodothyronine. Am J Clin Nutr. 2005;82(5):941-8.


Appendix

Appendix A – Participant Information Sheet

Government of Western Australia
Department of Health

Participant Information Sheet

Quantification of energy expenditure post-small to moderate burn injury – an observational study

Principal Investigator:
Assoc. Professor Dale Edgar - Burns Service of Western Australia

Associate Investigators:
Dr. Brad Wall – Murdoch University
Mr. Tyler Osborne – Murdoch University
Mr. Paul Gittings – Burns Service of Western Australia
W. Prof. Fiona Wood – Burns Service of Western Australia

Location:
Fiona Stanley Hospital

You are being invited to participate in this research study because you have recently been admitted to the Fiona Stanley Hospital (FSH) Burns Unit for treatment of a burn injury less than or equal to 15% of your total body surface area.

This information sheet explains the study and describes what will be involved should you decide to participate. Please read the information carefully and ask any questions you might have. You may also wish to discuss the study with a relative or friend.

You will be given a copy of this Participant Information and Consent Form to keep.

What is the purpose of this project?

After a burn injury, there is an increase in the daily energy needs of the body for wound healing and recovery. Research investigating this increase in energy need has focussed on major burns of more than 20% total body surface area. The energy needs of smaller burns (less than or equal to 15% total body surface area) is not well understood, yet most patients admitted to Fiona Stanley Hospital have a burn of this size.

To measure the amount of energy someone needs we can use an assessment tool known as indirect calorimetry. Indirect calorimetry has been used in research for more than 30 years to measure the energy needs of individuals with a burn injury. It is safe, non-invasive and accurate,
and is recommended by international guidelines as the best method to work out the energy needs of burn patients.

In this study we will investigate what the energy needs are of people with a small to moderate burn injury using indirect calorimetry. The results of this study will assist clinicians in providing the right amount of nutrition and exercise prescription to patients with a moderate burn. This project is a collaboration between the State Adult Burn Unit, Fiona Stanley Hospital and Murdoch University.

What does participation in this project involve?

If you decide to participate in this study you will have your resting energy needs measured using an indirect calorimeter. The measurements will aim to be:

1. Daily for 7 days with day 1 being the day following burn injury, and
2. One outpatient assessment: 10-13 days after admission.

The outpatient assessment will occur at the same time as one of your appointments in the Burns Service outpatient clinic meaning that extra travel will not be required.

The indirect calorimetry measurements will occur in the morning before breakfast as to be accurate, we need you to have nothing to eat or drink (water is ok) for at least 4 hours prior to the measurement. Before the measurement and during the measurement you will be asked to lie in bed in a comfortable position in a relaxed, awake (not asleep) position and remain as still as possible. You will be asked to insert a ‘snorkel like’ mouthpiece (picture below) which will collect your expired gases but in no way restriction your inspiration (breathing in).

We would also like to assess your nutritional and functional status each time the indirect calorimetry measurement is completed. This will be done through assessment tools which are
commonly used by Exercise Physiologists and Dietitians. The first is a body composition assessment via bioimpedance spectroscopy (BIS). This will be collected at the same time as your indirect calorimetry test. For this test you will have four (4) gel electrodes placed on one hand and foot and connected to a small device which will assess the amount of muscle and fat in your body. We will also complete a hand-grip strength test using a tool called a dynamometer. For this test, you will sit on the edge of your bed or in a chair with your preferred arm for writing at a 90-degree angle. You will then be asked to squeeze the handle for three seconds as hard as you can and then release. This will be repeated three times with a short break in-between. This measurement will take less than 5 minutes.

The other tool to determine your nutritional status is called a Patient Generated Subjective Global Assessment (PG-SGA). This tool is commonly used by dietitians and will take about 15 minutes to complete by an experienced researcher. You will be asked a series of questions about your food intake, weight history, activity level, and nutrition impact symptoms which include nausea and dry mouth. The researcher will then complete a quick, non-invasive physical assessment to look at your muscle and fat stores using spring calipers.

What are the possible benefits of taking part?

This study aims to understand the use of indirect calorimetry to patients with small to moderate burn injuries. While there will be no direct benefit to you from taking part in the study the information collected may benefit other patients with a burn injury in the future.

What are the possible risks and disadvantages of taking part?

The indirect calorimetry, body composition, hand grip strength, and PG-SGA are all pain-free non-invasive tests. You may experience mild discomfort during the indirect calorimetry as you are required to remain still for the duration of the test and be fasted for at least 4 hours. Some people may experience discomfort while wearing the mouthpiece piece. If you do experience discomfort during the measurement you will be able to communicate with the researcher and the measurement can be stopped immediately.

What will happen to information about me?

By signing the consent form you consent to the researcher collecting and using personal information about you for this project. Any information obtained in connection with this project that can identify you will remain confidential. All written information will be stored in a locked filing cabinet for a period of seven years at FSH and a copy at Murdoch, as required by law. All data
stored in a computer will be accessible only by password known to the principle investigator. Both written and electronic data will be de-identified and will not contain any identifiable information such as your name, address, or telephone number.

Information about you will be obtained from your health records at FSH for the purpose of this research. By signing the consent form you agree to the research team accessing health record data relevant to your participation in this study.

It is anticipated that the results of this study will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified.

In accordance with relevant Australian privacy and other relevant laws, you have the right to request access to the information collected and stored by the research team about you. You also have the right to request that any information with which you disagree be corrected. Please contact the research team member named at the end of this document if you would like to access your information.

Any de-identified information obtained for the purpose of this study may be used for future related research, subject to approval by a Human Research Ethics Committee.

Complaints and compensation

In the event that you suffer an expected or unexpected side effect or medical accident during this study that arises from your participation, you will be offered all full and necessary treatment by FSH.

Voluntary participation and withdrawal

Participation in any study is voluntary. If you do not want to take part, you do not have to. If you decide to take part and later change your mind you can withdraw at any stage without reason or justification. If you decide not to participate or you withdraw part-way through it will in no way affect your current or future care at FSH.

If you do withdraw consent during the project, the researcher will not collect additional personal information about you, although personal information already collected will be retained to ensure that the results of the study can be measured properly. You should be aware that data collected
by the researcher up to the time the participant withdraws will form part of the study results. If you do not want them to do this, you must tell them before joining the study.

What happens when the study ends?

The results of the study may be published in scientific journals or discussed at scientific meetings in the future. You can request a copy of the study report from the research team once it is written. If you would like a copy please inform the investigator.

Contacts for further information

If you would like further information about this project or if you have any medical problems which may be related to your participation, please contact Dr Dale Edgar on 0413070384 or dale.edgar@health.wa.gov.au.

This project will be carried out according to the National Statement on Ethical Conduct in Human Research (2007). This statement has been developed to protect the interests of people who agree to participate in human research studies. All research in Australia involving humans is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this project have been approved by the South Metropolitan Health Service (SMHS) and Murdoch University HRECs.

Whilst not intended to do so, if this project discovers information about illegal activity, researchers may be subject to orders to disclose this information to government agencies.

If you have any concerns about the conduct of the study or your rights as a research participant, please contact the SMHS Research Ethics and Governance Unit on 0151 1180 or SMHS.REG@health.wa.gov.au and quote the reference number RGS 13.

Supported By

[Images of logos for Fiona Stanley Hospital, Murdoch University, and Fiona Wood Foundation]
Appendix B – Informed Consent

Consent Form

Quantification of energy expenditure post-small to moderate burn injury – an observational study

Principal Investigator

Associate Professor Dale Edgar – Burn Service, Fiona Stanley Hospital

Associate Investigators

Dr. Brad Wall – Murdoch University
Mr Tyler Osborne – Murdoch University
Mr. Paul Gittins – Burn Service, Fiona Stanley Hospital
W. Professor Fiona Wood – Burn Service of WA

Location

Fiona Stanley Hospital

Declaration by Participant

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.
I am 18 years of age or over.
I understand the purposes, procedures and risks of the study described in the Information Sheet.
I have had an opportunity to ask questions and I am satisfied with the answers I have received.
I freely agree to participate in this study as described and understand that I am free to withdraw at any time without affecting my future health care.
I understand that I will be given a signed copy of this document to keep.

I give permission for my doctors, other health professionals, hospitals or laboratories outside this hospital to release information to Murdoch University concerning my condition and treatment for the purposes of this project. I understand that such information will remain confidential.

I give permission that any de-identified information obtained for the purpose of this study may be used for future related research.

Name of Participant (please print) ________________________________
Signature ________________ Date ________________

Declaration by Researcher

I have given a verbal explanation of the study, its procedures and risks and I believe that the participant has understood that explanation.

Name of Researcher (please print) ________________________________
Signature ________________ Date ________________
Appendix C – Murdoch Ethics Approval

Thursday, 23 February 2017

Dr Brad Wall
School of Psychology and Exercise Science
Murdoch University

Dear Brad,

Project No. 2016/228
Project Title Quantification of energy expenditure post-small to moderate burn injury - an observational study

Thank you for addressing the conditions placed on the above application to the Murdoch University Human Research Ethics Committee. On behalf of the Committee, I am pleased to advise the application now has:

OUTRIGHT APPROVAL

Approval is granted on the understanding that research will be conducted according the standards of the National Statement on Ethical Conduct in Human Research (2007), the Australian Code for the Responsible Conduct of Research (2007) and Murdoch University policies at all times. You must also abide by the Human Research Ethics Committee’s standard conditions of approval (see attached). All reporting forms are available on the Research Ethics and Integrity web-site.

I wish you every success for your research.

Please quote your ethics project number in all correspondence.

Kind Regards,

[Signature]

Dr. Erich von Dietze
Manager
Research Ethics and Integrity

cc: Prof Fiona Wood, Dr Dale Edgar, Mr Paul Gittings, Thomas Le Huray and Brodie Allan
Human Research Ethics Committee: Standard Conditions of Approval

a) The project must be conducted in accordance with the approved application, including any conditions and amendments that have been approved. You must comply with all of the conditions imposed by the HREC, and any subsequent conditions that the HREC may require.

b) You must report immediately anything, which might affect ethical acceptance of your project, including:
   - Adverse effects on participants
   - Significant unforeseen events
   - Other matters that might affect continued ethical acceptability of the project.

c) Proposed changes or amendments to the research must be applied for, using an Amendment Application form, and approved by the HREC before these may be implemented.

d) An Annual Report for the project must be provided by the due date specified each year (usually the anniversary of approval).

e) A Closure Report must be provided at the conclusion of the project (once all contact with participants has been completed).

f) If, for any reason, the project does not proceed or is discontinued, you must advise the committee in writing, using a Closure Report form.

g) If an extension is required beyond the end date of the approved project, an Extension Application should be made allowing sufficient time for its consideration by the committee. Extensions of approval cannot be granted retrospectively.

h) You must advise the HREC immediately, in writing, if any complaint is made about the conduct of the project.

i) Other Murdoch approvals (e.g. fieldwork approval) or approval form other institutions may also be necessary before the research can commence.

j) Any equipment used must meet current safety standards. Purpose built or modified equipment must be tested and certified by independent experts for compliance with safety standards.

k) Graduate research degree candidates must normally have their Program of Study approved prior to commencing the research. Exceptions to this must be approved by the HREC.

l) You must notify Research Ethics & Integrity of any changes in contact details including address, phone number and email address.

m) Researchers should be aware that the HREC may conduct random audits and / or require additional reports concerning the research project.

Failure to comply with the National Statement on Ethical Conduct in Human Research (2007) and with the conditions of approval may result in the suspension or withdrawal of approval for the project.

The HREC seeks to support researchers in achieving strong results and positive outcomes.
The HREC promotes a research culture in which ethics is considered and discussed at all stages of the research.

If you have any issues you wish to raise, please contact the Research Ethics Office in the first instance.
Appendix D – South Metropolitan Health Service Ethics Approval

Government of Western Australia
Department of Health

South Metropolitan Health Service Human Research Ethics Committee
Perkins South Building (Level 3), Fiona Stanley Hospital
11 Robin Warren Drive, Murdoch WA 6150

27 March 2017

Mr Paul Gittings
11 Robin Warren Drive
MURDOCH WA 6150

Dear Mr Gittings

PRN: RGS00000000013
Project Title: Quantification of energy expenditure post-small to moderate burn injury – an observational study
Protocol No: Version 1 9/12/2016

Thank you for submitting the above research project for ethical review. This project was considered by the South Metropolitan Health Service Human Research Ethics Committee at its meeting held on 27 March 2017.

I am pleased to advise you that the South Metropolitan Health Service Human Research Ethics Committee has granted ethical approval of this research project.

The nominated participating site in this project is:

Fiona Stanley Hospital

[Note: If additional sites are recruited prior to the commencement of, or during the research project, the Coordinating Principal Investigator is required to notify the Human Research Ethics Committee (HREC). Notification of withdrawn sites should also be provided to the HREC in a timely fashion.]

The approved documents include:

<table>
<thead>
<tr>
<th>Document</th>
<th>Version</th>
<th>Version Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Generated Subjective Global Assessment</td>
<td>1.00</td>
<td>04/01/2017</td>
</tr>
<tr>
<td>Cover Letter</td>
<td>1.00</td>
<td>22/02/2017</td>
</tr>
<tr>
<td>PIS</td>
<td>1.20</td>
<td>30/01/2017</td>
</tr>
<tr>
<td>Consent Form</td>
<td>1.20</td>
<td>30/01/2017</td>
</tr>
<tr>
<td>Murdoch HREC Approval</td>
<td>1.00</td>
<td>23/02/2017</td>
</tr>
<tr>
<td>Protocol</td>
<td>1.20</td>
<td>26/02/2017</td>
</tr>
</tbody>
</table>
Ethical approval of this project from South Metropolitan Health Service Human Research Ethics Committee is valid from 27 March 2017 to subject to compliance with the 'Conditions of Ethics Approval for a Research Project' (Appendix A).

The following project specific conditions must also be met:

A copy of this ethical approval letter must be submitted by all site Principal Investigators to the Research Governance Office or equivalent body or individual at each participating institution in a timely manner to enable the institution to authorise the commencement of the project at its site/s.

This letter constitutes ethical approval only. This project cannot proceed at any site until separate site authorisation has been obtained from the Chief Executive or Delegate of the site under whose auspices the research will be conducted at that site.

Should you have any queries about the South Metropolitan Health Service Human Research Ethics Committee's consideration of your project, please contact the Ethics Office at SMHS.REF@health.wa.gov.au or on 08 6151 1180. The HREC's Terms of Reference, Standard Operating Procedures and membership are available from the Ethics Office or from http://www2.health.wa.gov.au/About-us/South-Metropolitan-Health-Service/About-Human-Research-Ethics-and-Governance.

The HREC wishes you every success in your research.

Yours sincerely

[Signature]

MR RICHARD WOJNAR-HORTON
Chairman | South Metropolitan Health Service Human Research Ethics Committee
CONDITIONS OF ETHICS APPROVAL FOR A RESEARCH PROJECT

The following general conditions apply to the research project approved by the Human Research Ethics Committee (HREC) and acceptance of ethical approval will be deemed to be an acceptance of these conditions by all project investigators:

1. The responsibility for the conduct of this project lies with the Coordinating Principal Investigator (CPI).
2. The investigator recognises the reviewing HREC is registered with the National Health and Medical Research Council and that it complies with the current version of the National Statement on Ethical Conduct in Human Research.
3. A list of HREC member attendance at a specific meeting is available on request, but no voting records will be provided.
4. The CPI will immediately report anything that might warrant review of ethical approval of the project.
5. The CPI will notify the HREC of any event that requires a modification to the protocol or other project documents and submit any required amendments to approved documents, or any new documents, for ethics approval. Amendments cannot be implemented at any participating site until ethics approval is given.
6. The CPI will submit any necessary reports related to the safety of research participants in accordance with the WA Health Research Governance Standard Operating Procedures.
7. Where a project requires a Data Safety Monitoring Board (DSMB), the CPI’s will ensure this is in place before the commencement of the project and notify the HREC. All relevant reports from the DSMB should be submitted to HREC.
8. For investigator-initiated and collaborative research group projects the CPI may take on the role of the sponsor. In this case, the CPI is responsible for reporting to the Therapeutic Goods Administration (TGA) any unexpected serious drug or device adverse reactions, and significant safety issues in accordance with the TGA guidelines.
9. If the project involves the use of an implantable device, the CPI will ensure a properly monitored and up to date system for tracking participants is maintained for the life of the device.
10. The CPI will submit a progress report to the HREC annually from the ethics approval date and notify the HREC when the project is completed at all sites. The HREC can require additional reporting requirements as a special condition of a research project. Ethics approvals are subject to the receipt of these reports and approval may be suspended if the report is not received.
11. The CPI will notify the HREC of his or her inability to continue as CPI and will provide the name and contact information of their replacement. Failure to notify the HREC can result in approval for the project being suspended or withdrawn.
12. The CPI will notify the HREC of any changes in investigators and/or new sites that will utilise the ethics approval.
13. The HREC has the authority to audit the conduct of any project without notice if some irregularity has occurred, a complaint is received from a third party or the HREC decides to undertake an audit for quality improvement purposes.
14. The HREC may conduct random monitoring of any project. The CPI will be notified if their project has been selected. The CPI will be given a copy of the monitor’s report along with the HREC and Research Governance (RG) Office at the site/s.
15. Complaints relating to the conduct of a project should be directed to the HREC Chair and will be promptly investigated according to the WA Health’s complaints procedures.

16. The CPI should ensure participant information and consent forms are stored within the participant’s medical record in accordance with the WA Health’s Record Keeping Plan.

17. The CPI will notify the HREC of any plan to extend the duration of the project past the expiry date listed above and will submit any associated required documentation. A request for an extension should be submitted prior to the expiry date. One extension of 5 years may be granted but approval beyond this time period may necessitate further review by the HREC.

18. Once the approval period has expired or the project is closed, the CPI will submit a final report. If the report is not received within 30 days the project will be closed and archived.

19. Projects that do not commence within 12 months of the approval date may have their approval withdrawn and the project closed. The CPI must outline why the project approval should remain.

20. The CPI will notify the HREC if the project is temporarily halted or prematurely terminated at a participating site before the expected completion date, with reasons provided. Such notification should include information as to what procedures are in place to safeguard participants.

21. If a project fails to meet these conditions the HREC will contact the CPI to address the identified issues. If, after being contacted by the HREC, the issues are not addressed, the ethics approval will be withdrawn. The HREC will notify the RG Office at each site within WA Health that the project procedures must discontinue, except for those directly related to participant’s safety.
Date of Assessment:

Patient number: _______________ Gender: _______________

Admission information:

1. Has the patient been introduced to the project and informed consent gained?  YES
2. IPAQ completed?  YES  NO
3. Surgery?  YES  NO

Medical History:

<table>
<thead>
<tr>
<th>Infection status</th>
<th>Treatment Modality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Descriptive Data:

Height: ______ cm   Weight: ______ kg   TBSA: ______ %

Day Before Testing:

1. Dietary Intake and appetite collected:  YES  NO

Day 4 Testing:

1. Dietary Intake and appetite collected:  YES  NO

Grip strength (kgs):

<table>
<thead>
<tr>
<th>Grip</th>
<th>Trial 1 (Pre-Post)</th>
<th>Trial 2 (Pre-Post)</th>
<th>Trial 3 (Pre-Post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Hand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Hand</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Resting metabolic rate:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Day 4</th>
<th>Pre-surgery</th>
<th>Post-surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCO2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heart Rate: _______ bpm  
Body Temperature: ______ °C

Bioimpedance File (whole body)

File Name: __________________  
           mfu______________
INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?
   
   _____ days per week
   
   [ ] No vigorous physical activities  → Skip to question 3

2. How much time did you usually spend doing vigorous physical activities on one of those days?
   
   _____ hours per day
   _____ minutes per day
   
   [ ] Don’t know/Not sure

Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.
   
   _____ days per week
   
   [ ] No moderate physical activities  → Skip to question 5

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.
4. How much time did you usually spend doing moderate physical activities on one of those days?

______ hours per day
______ minutes per day
☐ Don't know/Not sure

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

______ days per week
☐ No walking ➔ Skip to question 7

6. How much time did you usually spend walking on one of those days?

______ hours per day
______ minutes per day
☐ Don't know/Not sure

The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the last 7 days, how much time did you spend sitting on a week day?

______ hours per day
______ minutes per day
☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.
Appendix G – Visual Analog Scale (Appetite)

Visual Analogue Scale [Appetite]

Participant ID#: ______________

Name: ______________________

Date: ______________________

Intervention Group: amEX / pmEX (please circle)

Time: (please check appropriate box)

<table>
<thead>
<tr>
<th>Pre – Standardised Meal O1</th>
<th>Immediately Post – Standardised Meal O1</th>
</tr>
</thead>
<tbody>
<tr>
<td>30min Post – Standardised Meal O1</td>
<td>60min Post – Standardised Meal O1</td>
</tr>
<tr>
<td>90min Post – Standardised Meal O1</td>
<td>120min Post – Standardised Meal O1</td>
</tr>
<tr>
<td>Pre – Standardised Meal O2</td>
<td>Immediately Post – Standardised Meal O2</td>
</tr>
<tr>
<td>30min Post – Standardised Meal O2</td>
<td>60min Post – Standardised Meal O2</td>
</tr>
<tr>
<td>90min Post – Standardised Meal O2</td>
<td></td>
</tr>
</tbody>
</table>

1. How hungry do you feel?

   Not hungry at all                               As hungry as I have ever felt

2. How full do you feel?

   Not full at all                                As full as I have ever felt
3. How strong is your desire to eat right now?

<table>
<thead>
<tr>
<th>Very weak</th>
<th>Very strong</th>
</tr>
</thead>
</table>

4. How much do you think you could eat right now?

<table>
<thead>
<tr>
<th>Nothing at all</th>
<th>A large amount</th>
</tr>
</thead>
</table>

|----------------|----------------|

Appendix H – Dietary Intake Record Sheet

**DIETARY INTAKE RECORD**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Food/Beverage Item</th>
<th>Not Taken</th>
<th>Refused</th>
<th>Percent (%) Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breakfast:</strong></td>
<td>Cereal (hot/cold) with Milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toast</td>
<td>Slices</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fruit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot Breakfast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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**Comments:**

Name: ____________________________ Signature: ____________________________
Appendix I – Burns Journal Author Information Guidelines

BURNS
Journal of the International Society for Burn Injuries

AUTHOR INFORMATION PACK

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DESCRIPTION

Burns aims to foster the exchange of information among all engaged in preventing and treating the effects of burns. The journal focuses on clinical, scientific and social aspects of these injuries and covers the prevention of the injury, the epidemiology of such injuries and all aspects of treatment including development of new techniques and technologies and verification of existing ones. Regular features include clinical and scientific papers, state of the art reviews and descriptions of burn-care in practice.

Topics covered by Burns include: the effects of smoke on man and animals, their tissues and cells; the responses to and treatment of patients and animals with chemical injuries to the skin; the biological and clinical effects of cold injuries; surgical techniques which are, or may be relevant to the treatment of burned patients during the acute or reconstructive phase following injury; well controlled laboratory studies of the effectiveness of anti-microbial agents on infection and new materials on scarring and healing; inflammatory responses to injury, effectiveness of related agents and other compounds used to modify the physiological and cellular responses to the injury; experimental studies of burns and the outcome of burn wound healing; regenerative medicine concerning the skin.

Burns seeks to publish suitable material submitted by all professions involved in the care, treatment and prevention of burn injuries.

Burns has an Impact Factor of 1.950 in the 2010 Journal Citation Reports®, published by Thomson Reuters.

AUDIENCE

Burns surgeons, plastic surgeons, anaesthetists, intensivists, researchers, nursing staff, paramedics, dieticians, physical therapists, occupational therapists, sociologists and epidemiologists.

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GUIDE FOR AUTHORS

INTRODUCTION
Burns aims to foster the exchange of information among all engaged in preventing and treating the effects of burns. The journal focuses on clinical, scientific and social aspects of these injuries and covers the prevention of the injury, the epidemiology of such injuries and all aspects of treatment including development of new techniques and technologies and verification of existing ones. Regular features include clinical and scientific papers, state of the art reviews and descriptions of burn-care in practice.

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If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.
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