An Assessment and Analysis of Dietary Practices of Irish Jockeys

Thesis submitted for the degree of Research Masters.

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Declaration

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Abstract

Background: Horse racing is a weight category sport in which jockeys must chronically maintain a low body mass to compete, over a protracted season. The need to relentlessly align body mass with racing limits appears to encourage the use of short-term and potentially dangerous acute weight loss strategies. The purpose of this study was to investigate and assess the dietary habits of Irish Jockeys using established methods as well as incorporating novel sensing technologies. **Methods:** The primary aim was achieved through two separate but related studies. *Study one:* Dietary intake was assessed in 18 professional Irish Jockeys (11 Flat and 7 National Hunt) over a typical racing week, using a standard 7-day food diary. *Study Two:* There are limitations associated with the traditional methods of dietary assessment therefore a new innovative method of dietary assessment using novel sensing technologies, the Microsoft SenseCam, a wearable camera, was evaluated. The SenseCam was worn by 17 trainee jockeys in tandem with keeping a standard 1-day food diary to increase the accuracy of the dietary assessment. For the purposes of comparison, the study was then broadened to two further populations, elite Gaelic footballers and a group of healthy active University Students to evaluate potential differences across populations. **Results:** In study one the dietary analysis showed mean daily energy intake (1803±564 kcal) was low in both Flat and National Hunt groups alike and appeared to provide insufficient availability of energy for sustainment of usual daily and metabolic processes. Carbohydrate intake (3.7 ±1.3g.kg^{-1}) was below recommendations for athletes, whilst protein levels (1.3 ± 0.5. kg^{-1}) were within recommended amounts for athletes. In general the levels fell short of the recommendations for athletes partaking in weight category sports. Jockeys consumed well below (0-2) the recommended five daily servings of fruit and vegetables set by the World Health Organization. Study two showed that by using the SenseCam in tandem with the 1-day food diary a more accurate dietary assessment could be gleaned. Mean total calorie intake using the food diary alone compared to the combination of the food diary and SenseCam were 2349±827.9 vs 2631±893.4 kcal, 2600±521.9 vs 3191±770.2 kcal and 2237±318.5 vs 2487±404.6 kcal for the trainee jockeys, Gaelic footballers and University students respectively. This represented a difference of 10.7% (p≤0.001); 17.7% (p≤0.001); and 10.1% (p≤0.01) among measurements methods for trainee jockeys, Gaelic footballers, and university students, respectively. The SenseCam allowed the dietitian to pick up on foods consumed but not documented in the food diary. It also allowed identification of brand types and portions size making the overall dietary assessment more accurate. **Conclusions:** Results from this research suggest that due to the chronically energy restricted lifestyle associated which Irish professional jockey, this may place them at risk of compromised long term health. By using novel sensing technologies it may be possible to more accurately assess dietary intake in this population, in order to assist in the education and provision of more accurate dietary advice in the future.

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Glossary of Terms

Making Weight

The practice typically used by weight category athletes to attain the required competition weight.

Weight/Claiming Allowance

Apprentice jockeys just starting out their career are granted a weight allowance to encourage trainers and owners to allocate rides to the more inexperienced jockeys. Apprentices may ride at a lower weight (up to 10lb/4.5 kg) than that actually allocated to the horse until a certain amount of winners are achieved. The claiming allowance is progressively reduced in accordance with the number of wins accumulated by an apprentice. It is then expected the apprentice has established a worthy reputation, no longer relying on the claiming incentive to secure rides in races.

Flat Racing

Flat races are started from the stalls, range from distances of 1 to 4 km and consist of a run in which no obstacles are present. The weight classifications for flat racing in Ireland range from 52.7 to 64 kg.

National Hunt Racing

NH races are started from a tape barrier and involve a number of fences or hurdles over which the horse must jump, covering distances of at least 3.2 km up to 7.2 km. The weight allocations for national hunt racing in Ireland range from 62 to 76 kg.

Osteoporosis

Osteoporosis has been defined as "a progressive systemic skeletal disease characterized by low bone mass and micro architectural deterioration of bone tissue, with consequent increase in bone fragility and susceptibility of fracture" (Anonymous, 1993).

Osteopenia

Osteopenia is a precursor to osteoporosis.

Thoroughbred Horses:

The horses used in thoroughbred horse-racing. A purebred horse which originates from the breeding of native English mares with one of three imported Arabian stallions.

Weight Cycling

Weight cycling can be defined as periods of weight loss interspersed by periods of subsequent weight gain.

List of abbreviations

BMD: Bone Mineral Density

BMI: Body Mass Index

DEXA: Dual-Energy X-ray Absorptiometry

DCU: Dublin City University

EE: Energy Expenditure

EEE: Estimated Energy Expenditure

EI: Energy Intake

FFM: Fat Free Mass

FFQ: Food Frequency Questionnaire

FNDSS: Food and Nutrition Database for Dietary Studies

LBM: Lean Body Mass

LER: Low Energy Reporter

HRI: Horse Racing Ireland

NH: National Hunt

PDA: Personal Digital Assistant

RACE: Racing Academy and Centre of Education

RDA: Recommended daily allowance

REE: Resting Energy Expenditure

RMR: Resting Metabolic Rate

TADA: Technologically Assisted Dietary Assessment

TEE: Total Energy Expenditure

WHO: World Health Organisation

Related publications

Peer reviewed Journals

O'LOUGHLIN, G., CULLEN, S., MCGOLDRICK, A., O'CONNOR, S., BLAIN, R., O'MALLEY, S. & WARRINGTON, G. D. 2013. Using a Wearable Camera to Increase the Accuracy of Dietary Analysis. *American Journal of Preventive Medicine,* 44**,** 297-301.

DOLAN, E., O'CONNOR, H., MCGOLDRICK, A., O'LOUGHLIN, G., LYONS, D. & WARRINGTON, G. 2011. Nutritional, lifestyle and weight control practices of professional jockeys. *Journal of Sports Sciences,* 29**,** 791-799.

DOLAN, E., O'CONNOR, H., O'LOUGHLIN, G., MCGOLDRICK, A., & WARRINGTON, G. 2010b, Nutritional and Lifestyle Practices of the Horse Racing Jockey, *Journal of Sports Science.*

DOLAN, E., WARRINGTON, G., MCGOLDRICK, A., O'LOUGHLIN, G. & MOYNA, N. M. 2008. Analysis of energy balance of professional jockeys on a competitive race day. *Medicine and Science in Sports and Exercise,* 40**,** S14.

WALDRON-LYNCH, F., MURRAY B F, BRADY J J, MCKENNA M J, MCGOLDRICK A, O'LOUGHLIN G & BARRAGY J M 2010. High bone turnover in Professional Jockeys. *Osteoporosis International* 21**,** 521-525.

List of Poster presentations

O'LOUGHLIN, G., CULLEN, S., MCGOLDRICK, A., WARRINGTON, G. 2011 *Using the SenseCam to increase the accuracy of dietary intake of jockeys.* Clarity Conference Dublin – Croke Park, Dublin.

Chapter One: Introduction

1.1 Background Information & Justification

Horse racing is a weight category sport, which necessitates the jockeys to maintain a strict body mass in order to compete. The need to relentlessly align body mass with racing limits appears to encourage the use of short-term and potentially dangerous acute weight loss strategies in an attempt by jockeys to optimize riding opportunities (Hill and O'Connor, 1998). Evidence suggests that one of the main methods employed by jockeys to 'make weight' are severe food and fluid restriction (Dolan et al., 2011b, Labadarios et al., 1993, Leydon and Wall, 2002, Moore et al., 2002, Cotugna et al., 2010). Although this may not create a challenge in the short term, the requirement to make weight on numerous occasions throughout the course of an extended racing season and the ongoing need to maintain body mass within strict limits may lead to compromised nutritional status in this population (Warrington et al., 2009). Research has shown jockeys to be a population with low energy availability Dolan et al., (2011c), poor bone health Dolan et al., (2009); Waldron-Lynch et al., (2010); Warrington et al., (2009)(Dolan et al., 2011a, Waldron-Lynch et al., 2010, Warrington et al., 2009) and altered hormonal function Dolan et al., (2012b), all of which may indicate that jockeys may be susceptible to elements of the "Female Athlete Triad" (Nattiv et al., 2007).

Rapid weight loss through acute weight loss practices is well documented in many weight category sports, such as wrestling, where steps were taken to introduce a certified weight system after the death of three collegiate wrestlers occurred (Sundgot-Borgen and Garthe, 2011). It is recommended that any body mass loss necessary for competition should be undertaken over a period of greater than seven days, and ideally during off season to avoid interference with competitions, Sudi et al., (2004b); Sundgot-Borgen & Garthe (2011), with a gradual weight loss of ~ 0.5kg per week (Sundgot-Borgen and Garthe, 2011). This however in reality this is not a viable weight regulation strategy for jockeys as they race throughout the year and are therefore provided with little opportunity for respite from the rigours of making weight. A jockey may have up to 6 races in a day, possibly at different weights, with a lack of opportunity to replenish energy stores or rehydrate before, during or after each race due to the requirement to weigh-in immediately before and after each race. Previous research suggests that jockeys appear to follow a chronically energy restricted lifestyle Labadarios et al., (2003); Leydon & Wall, (2002) accompanied by regular use of rapid weight loss strategies, including both active and passive dehydration, such as saunas, exercising while wearing heavy clothing or sweat suits as well as the use of diuretics, laxatives and in some cases self- induced vomiting (Wilson, 2012, Leydon and Wall, 2002). Previous research would also suggest that the majority of jockeys have no defined strategy for optimally managing and achieving the required body mass reduction, adopting strategies from their peers which are based mainly on tradition and have no scientific basis (Moore et al., 2002). This may place them at increased risk of reduced physiological and cognitive function Dolan et al., (2011a) as well as potentially compromising long term health. Due to their restricted calorie intake Jockeys have a very small energy window in which to achieve their nutrient intake requirements. This is further compounded by the virtue that previous research would suggest a heavy reliance on energy dense convenience foods low in micronutrients (Labadarios et al., 1993, Dolan et al., 2011b). Despite this, to date, little research has been undertaken to examine the specific energy demands and nutritional needs of the jockey, making it difficult to develop appropriate nutritional and training guidelines for this group. It is imperative that further research is done to build a scientific evidence base in order that sport specific advice can be delivered to jockeys and help reduce the reliance on the unhealthy weight making practices currently employed.

1.2 Purpose of the Research

Given that jockeys undertake extreme weight loss measures to 'make weight' on a regular basis, they are at increased risk of dehydration in the short term and in the longer term, chronic under – nutrition and energy deficiency. Previous research has shown that jockeys have reduced bone mass, low body fat stores and are regularly hypo hydrated (particularly on race days), all of which were attributed to their restrictive lifestyle (Warrington et al., 2009). The purpose of this study therefore was to examine the dietary habits of Irish jockeys, to establish an accurate picture of dietary practices employed by the jockeys and to investigate whether or not they were meeting their nutritional needs for long term health and well-being.

1.3 Research Aims and Objectives

1.3.1 Study One: Nutritional practices of Professional Irish Jockeys

Aim

The aim of this study was to evaluate the dietary practices and examine the nutritional adequacy of the diets of professional Irish Jockeys.

Objectives

To analyse the dietary intake of a group of professional Irish Jockeys, using a 7-day food diary.

To evaluate differences between the dietary intake of professional flat and national hunt jockeys.

Hypothesis

Jockeys have habitually low energy intakes which are not aligned to the recommended dietary guidelines for weight category athletes.

There is a significant difference between the dietary intake of professional flat and national hunt jockeys.

1.3.2 Study Two: A comparison and validation of dietary analysis of a standard one-day food diary and the SenseCam in three different sporting populations.

Aim

To examine the use and impact of a novel sensing technology in the form of the Microsoft SenseCam wearable camera to help more accurately report dietary intake within different physically active and athletic populations.

Objectives

- To collect a one day food diary and image data from SenseCam from each participant.
- To analyse reported calorie intake using WinDiets food data base to obtain a total nutrient summary of the food diary.
- To compare the total nutrient summary from the food diary alone and the combination of the food diary and SenseCam to evaluate potential discrepancies in the former.
- To compare the result from the jockeys with those for elite Gaelic footballers and healthy active university students

Hypothesis

1. There will be a significant difference in reported calorie intake associated with traditional one day food diaries compared to the calorie intake of a one day food diary in conjunction with SenseCam image data.
2. There will be a significant difference in mean energy intakes between the three populations.

1.4 Delimitations

Study 1:

This study was restricted to male professional jockeys. Professional female jockeys are in the minority in Ireland and so if used would have resulted in a small sample size. All the participants were currently licensed by the Irish Turf Club.

Study 2

This study was restricted to trainee jockeys attending Racing Academy and Centre of Education (RACE).

1.5 Limitations

The specific limitations associated with each study are included in the individual study chapters (see chapters 3 and 4).

1.6 Summary

The purpose of this study was to further investigate the dietary habits of Irish Jockeys. To identify any nutritional inadequacies which through the constant weight making practices may put the jockeys at increased risk of nutritional deficiencies and consequently both short-term and long-term risks to their performance, health and overall well-being. This thesis will begin with a review of the relevant scientific literature (Chapter 2) followed by two independent, though related studies (Chapters 3 and 4) as outlined above. Finally, a summary (Chapter 5) will conclude this thesis outlining the practical implications of the research and recommendations for future based on the research findings.

Chapter Two: Literature Review

2.1 Horse Racing - A Weight Category Sport

2.1.1 Horse Racing in Ireland

Competitive horse racing is one of the first known competitive sports, originating among the prehistoric nomadic tribesmen of Central Asia, who first domesticated the horse around 4500 BC. Today, thoroughbred horse racing is one of Ireland's most popular sports, and one in which the country can claim significant international success. Horse racing in Ireland is governed by Horse Racing Ireland (HRI). The Turf Club is the regulatory body for horseracing in Ireland, and is solely responsible for making and enforcing the rules of racing in Ireland. It has been estimated that horse racing and breeding sector contribute almost €1 billion to the Irish economy, employing in excess of 16,000 people and is responsible for annual exports worth €174 million (HRI 2012). Known as 'The Sport of Kings', horse racing attracts followers from every age, nationality and walk of life, last year alone attracted 1.2 million race goers (HRI, 2012). There are 26 race courses in Ireland; in 2012 they hosted 350 race meetings (119 Flat, 179 National Hunt, 52 both) this amounted to 2156 races in total (1084 Flat; 1432 National Hunt)(HRI, 2012).

Irish horses compete in two main types of races, namely Flat and National Hunt. Flat races are started from the stalls, range from distances 1-4 km and consist of a run in which no obstacles are present. National hunt races are started from a tape barrier and involve a number of fences or hurdles over which the horses must jump, covering distances of at least 3.2 km up to 7.2 km.

Professional jockeys in Ireland can be categorised into the following categories: apprentice, conditional and professional. Apprentice and conditional jockeys are young professional flat and national hunt jockeys respectively. The pathway which Irish jockeys take to enter the world of horse racing can vary from those who have grown up with racing and participate in pony racing and then go on to become apprentice jockeys and those who enter the Racing Academy and Centre of Education (RACE). Typically the age of entrants to RACE is between 16 – 20 years. Completion of the 1 year course at RACE enables some participants to sign on as apprentice jockeys while others go on to work in other areas related to the equestrian industry.

An integral feature of horse racing is that of handicapping. All race horses must carry a designated weight, which is allocated based on the ability of the horse. Racing jockeys must comply with the weight allocation which is placed on the horse that they are riding. In Ireland the weight classifications range from 52.7kg to 64 kg and 62 to 76 kg for flat and national hunt jockeys respectively (Warrington et al., 2009). To encourage trainers to give in-experienced (apprentice/conditional) jockeys an opportunity to ride, they are allowed a further weight allowance known as a ‘claim’ of up to 10lbs. This claiming allowance is gradually reduced in accordance with the number of wins accumulated by the apprentice. These weight allocations appear to be based more on tradition than on sound scientific principles, with little evidence of change since the early 1900’s (Warrington et al., 2009). The Irish population are increasing in size and stature (Whelton et al., 2007). Analysis of the records of trainee jockeys entering RACE 30 years ago shows an increase in the body mass of a new entrant of 47% (13.6 kg) while the minimum racing weight for a flat jockey has risen by just 10% from 47.7 – 52.7 kg.

2.1.2 Horse Racing – A Weight Category Sport

Horse racing is a dangerous sport and is reported to have a higher risk of fatality than other high risk sports such as skydiving, motorcycling and boxing (Hitchens et al., 2009). Thoroughbred horses weigh up to 500 kg, are capable of speeds up to 60 km/h and are often ridden by jockeys weighing less than 50 kg (Dolan et al., 2011b). Horse racing is a weight category sport and as such jockeys are subject to many of the challenges typically associated with participation in sports of this nature. It is a highly competitive and high risk past-time that requires the jockey to have strength, balance and the ability to maintain high levels of concentration (Hitchens et al., 2009). Weight allocations in horse racing are based solely on the ability of the horse. This makes horse racing a unique weight category sport, unlike other weight classification sports the jockey does not have specified weight category at which they must compete. Instead each jockey must align their body mass with the weight assigned to the mount that they are riding in each individual race, in some cases jockeys could race in 5 – 7 races per day. This poses major challenges to jockeys, due to the large variability and lack of predictability related to the specific weight targets that jockeys must meet can increase the pressure placed on this unique athletic population and there are few jockeys who are naturally lightweight thereby avoiding the on-going battle of trying to make weight (Leydon and Wall, 2002, Warrington et al., 2009).

2.1.3 Nutritional Practices of Jockeys

A jockey typically leads a demanding and hectic lifestyle and faces many challenges, none bigger than that of 'making weight' and maintaining a low body mass. Current literature on a range of weight category sports suggests that making weight for competition can be detrimental to the health and performance of the athlete (Walberg Rankin, 2006, Sundgot-Borgen and Garthe, 2011). The most dramatic and unfortunate result of efforts to rapidly reduce body mass in the sport of wrestling was the death of three collegiate wrestlers in 1997 trying to 'make weight' American Medical Association, (1998), the deaths of two American jockeys were also reported to be related to the effects of chronic weight control and energy restriction (Scheinemann, 2005, Finley, 2005). The detrimental effects of 'making weight' may be exacerbated for the horse racing population due to the length and intensity of the horse racing season, and lack of opportunity to replenish their fuel and fluid stores before, during and after racing. At many race tracks in Ireland there is a lack of provision of appropriate catering making it even harder for the jockey to refuel appropriately (RACE report 2006).

Professional jockeys have previously been reported to use several, often extreme methods to make weight including restricted calorie and fluid intake, self- induced vomiting, saunas, exercising while wearing sweat suits', diuretics and laxatives (Leydon and Wall, 2002, Moore et al., 2002, Warrington et al., 2009, Brownell et al., 1987, Oppliger et al., 1996, Sawka et al., 2007, Wilson, 2012). Horse racing is a unique weight classification sport, which is unlike many weight category sports such as wrestling, judo, boxing, light weight rowing by virtue of the fact that jockeys must compete at their designated weight as well as weigh in immediately before and after each race. This makes it difficult for jockeys to adequately refuel and rehydrate between races. A further challenge to jockeys is they are often required to ride at different weights on the same day and may only have received 24- 48 hours prior notice (Dolan et al., 2011b, Wilson, 2012).

Studies evaluating diet and lifestyle characteristics of jockeys have found that typical dietary intake is low in energy and inadequate in key micronutrients (Leydon and Wall, 2002, Labadarios et al., 1993, Moore et al., 2002). Leydon and Wall, (2002) examined the dietary practices of 20 professional jockeys in New Zealand and found that energy and carbohydrate intakes were below those recommended for athletes and similar to those reported more recently by Dolan et al., (2011b) that there were deficiencies in micronutrients. More than

50% off the sample in Dolan et al., (2011) failed to meet the estimated average requirement for vitamins A and C, riboflavin, folate, calcium, and Zinc. A worrying proportion of jockeys also consumed less than the lower threshold intake for folate (55%), vitamin C (38%), vitamin A (27%), and calcium and zinc (11%). Similarly Labadarios et al., (1993) studying the dietary habits of 93 professional jockeys found that the jockeys' diets were lacking in carbohydrate and other micronutrients. It was reported that the jockeys had as a group no strategy for long term body weight management and relied almost exclusively on traditional methods of weight control, through fasting and dehydration, with approximately 70% of the jockeys following a 'binge/fast' cycle once or twice a week. This study also found that 80% admitted to skipping meals on a regular basis due to fear of gaining weight. Both studies found that Jockeys consumed more than the recommended amount of fat per day. This may be a reflection on lack of nutritional knowledge in this group, leading to poor dietary choices.

2.1.4 Risks Associated with Weight Making Practices in Jockeys

A number of studies have suggested that severe energy restrictions which accompany acute weight loss may have consequences for bone health in weight category athletes (Walberg Rankin, 2006, Proteau et al., 2006, Warrington et al., 2009). It is thought that this may be due to energy and micronutrient deficiencies, and to the hormonal readjustments which occur as a result of reduced energy availability. In a study by Dolan et al., (2011a) comparing bone mass between two groups of weight category athletes: national hunt jockeys and elite amateur boxers as well as age, gender and BMI matched controls, the authors found reduced bone mass in the group of jockeys and postulated that this may be a consequence of reduced energy availability in response to chronic weight restriction. A high level of bone mass was identified in the boxing group; this may be attributed to the oestrogenic benefits associated with high impact activity. Overall the study found low bone mass in both jockey groups and high bone mass in the boxer group, when compared to an age, gender and BMI matched control group (Dolan et al., 2011a). The study also outlined the possible implications for this group of athletes in light of the high risk nature of their sport. Another study looking at bone health and bone metabolism reported high rates of bone turnover in a group of Irish jockeys (Waldron-Lynch et al., 2010). Again the author attributed the findings of the study to inappropriate dietary practices and weight making strategies. Fogelholm et al., (1994) found that rapid weight loss in wrestlers was associated with increased risk of stress fractures and impaired physical performance.

Weight making practices already outlined can result in varying degrees of fatigue and dehydration, and if taken to the extreme can place the athlete at an increased risk of decreased physical and cognitive performance, thermal stress and a variety of other health complications (Fogelholm, 1994, Sawka et al., 2007). Warrington et al., (2009) examined hydration status in 27 Flat and National hunt jockeys. Results of the hydration analysis indicated that the jockeys studied appeared to be habitually dehydrated in an attempt to make weight for racing, a situation that may be further exacerbated on racing days. The mean USG values of the 27 professional jockeys revealed moderate levels of dehydration on non-race day (USG = 1.022 ± 0.005) and marked dehydration on race day (USG =1.0208±0.005) Furthermore 54% of these jockeys were reported to be competing in a severely dehydrated state (USG >1.030)(Warrington et al., 2009). Labadarios et al., (1993) reported that 96% of the South African Jockeys studied avoided consuming fluids between races for fear of gaining weight. Moore et al., (2002) undertook a study with Australian jockeys and reported that 10% of both professional (A Grade) and apprentice jockeys reported that they abstained from consumption of any food or fluid in the 24 hours prior to racing and 41 % used the sauna to achieve rapid weight loss while 39% used diuretics.

2.1.5 Psychological Effects of Weight Cycling

A number of studies have investigated the association between rapid weight loss through self–induced dehydration and starvation and the detrimental effects on mood and short term memory (Caulfield and Karageorghis, 2008). In addition to mood-related effects of severe weight control, it has been suggested that athletes who participate in weight-category sports may be more vulnerable to the development of disordered eating patterns which can lead to a serious eating disorder (Fogelholm, 1994, Sundgot-Borgen and Garthe, 2011). Making weight is part of the culture of racing with jockeys who repeatedly battle with their weight through starvation and dehydration methods are, to a degree, glamorized by the racing industry, and congratulated by owners, trainers and the media (Caulfield and Karageorghis, 2008). Weight management strategies employed by jockeys are principally based on tradition and generally passed on from peers as health professionals appear to be rarely consulted. Jockeys accept that dieting is part of the job as top American jockey John Valezquez said "The other professional athletes have to be stronger, bigger, faster. We have to be smaller, skinnier, lighter – and stronger at the same time. There is a lot of discipline involved, not a lot of people can do it” and when asked if he thought these weight making practices were normal he replied ”No its not normal . It’s part of my life, it comes with the territory”(Rosenblatt, 2008).

To summarise, in order to achieve rapid weight loss jockeys will employ a number of extreme methods putting their health at risk , however many see it as a necessary part of the sport and few jockeys appear to question the weight loss methods used (Hall and Lane, 2001).

2.2 Dietary Assessment Methods

Over the past 20 years, research has documented the beneficial effects of nutrition on exercise performance (ACSM et al., 2000, American Dietetic Association, 2009). There is no doubt that what an athlete eats and drinks can effect health, body weight and composition, substrate availability during exercise , recovery time after exercise and ultimately , exercise performance (ACSM et al., 2000). In clinical practice, dietary assessment involves collecting information on dietary intakes and then interpreting food or nutrient intakes against reference measures. Collecting dietary intake data and appropriately applying any population reference measures (Recommended daily amounts (RDA)) is not a simple process but one that requires care, precision and a high degree of skill and knowledge at all stages (Deakin, 2010). In order to fully investigate the claims that jockeys are living and working in an energy deficient state it is necessary to further examine the data collection methodologies by which this dietary information is gathered. This may include appraisal of methods of dietary assessment and analysis as well as identification of innovative and novel technologies which may enhance precision and accuracy of dietary assessment.

This section of the literature review will identify and evaluate the different methods of dietary assessment available to researchers and practitioners, highlighting potential advantages and disadvantages and limitations. Dietary intake is measured in terms of food intake and not in terms of energy and nutrient intake. Therefore dietary intake measurements provide only a guide to and not a direct measure of the amounts of energy and nutrients available for metabolism (Rutishauser, 2005). It is important to consider the aim of the planned study and the population itself when selecting a particular dietary assessment method (Magkos and Yannakoulia, 2003).

Techniques for measuring dietary intake are generally categorized into two main types: 1) current dietary intakes (prospective) and 2) past dietary intakes (retrospective). Ultimately the method adopted will depend on the level of information sought and the resources available (Magkos and Yannakoulia, 2003, Rutishauser, 2005).

2.2.1 Diet records – Prospective Method

Diet records, also referred to as food records, are considered the most accurate and feasible method for research (Black, 2001, Magkos and Yannakoulia, 2003).

1. A weighed food record is generally regarded as the gold standard against which other or new methods are compared or validated (Bingham, 1987). To increase accuracy it has been recommended that the weighed food record should be kept on several occasions 2 to 3 months apart (Black, 2001). A weighed food intake method requires the participant to weigh all foods and leftovers and document results as they go. This can be quite onerous on the participant and problematic when eating outside of the home. The principal limitation of this method is the high respondent burden which leads to non-compliance and often an altering of habitual intake which then introduces bias (Black, 2001). This method also requires a certain level of intellectual ability to understand what is required and dexterity to use the equipment. It can be expensive as it requires purchasing of recording equipment (Thomas and Bishop, 2007).

2. A non - weighed food record is similar to the above however the foods and beverages are not weighed. Instead amounts are described and recorded as accurately as possible using household measures and descriptions of portion size, labels and brands. This method still requires a certain level of literacy skills but tends to be more acceptable. It is more suitable for participants who frequently eat outside of the home and is not as expensive to do. In a review of dietary surveys of athletes by Burke et al., (2001) 3-4 day diet records using household measures was the most commonly used with athletes. Periods more than 7 consecutive days are not practical due to respondent fatigue (Magkos and Yannakoulia, 2003). One advantage of the dietary record method is that it provides quantitatively accurate information on food intake during the recording period. The fact that foods are being recorded as they are consumed is another of its strengths; omission of foods is then

decreased. In addition it would seem respondents find it easier to record amounts of food consumed while eating rather than attempting to recall portion sizes after a meal (Thompson and Byers, 1994). Once the record/diary has been collected the trained interviewer/dietitian must review the recorded information with the participant to clarify any ambiguities. The information is then coded and put through a dietary analysis package. This can be labour intensive and will increase the cost of the exercise(Thomas and Bishop, 2007). A certain level of co-operation and motivation is required which inevitably alters habitual intake. A certain level of literacy is also required, potentially limiting the method's use in some population groups (e.g. low socioeconomic status, recent immigrants, children and some elderly groups, not to mention young athletes with poor levels of education) (Magkos and Yannakoulia, 2003). The main challenge with this method is misreporting due to a number of reasons which will be discussed in a later section (page19 section 2.3.3 and 2.3.3.1).

2.2.2 Diet History – Retrospective Method

1. Dietary history is an interview method consisting of three stages:

   Stage 1: A 24 hour dietary recall.

   Stage 2: An assessment of usual intake. Portion sizes can be assessed using a food atlas and with the aid of standard spoons, cups and plastic food replicas.

   Stage 3: A check list of common foods, used to cross- check information obtained earlier.

It is important to avoid 'leading questions' which may influence study outcomes therefore this method should preferably be undertaken by a trained interviewer/qualified dietitian. This method is time consuming taking up to an hour per subject. Retrospective methods are hugely dependent on the respondent's memory and honesty (Black, 2001, Thomas and Bishop, 2007).

2.2.3 Food Frequency Questionnaire – Retrospective Method

A food frequency questionnaire (FFQ) contains a list of foods and drinks. The participant is asked to record how often they usually consume each item. If questions about the amount of foods consumed are included it is termed a semi-quantitative FFQ. The questionnaire can be self-administered or administered by an interviewer. It can be completed by paper or by computer depending on the population being studied.

Advantages of this method:

- This method works well in large-scale population studies in relationships between diet and risk of disease.
- It is useful in assessing change in diet after dietary advice has been given.

Disadvantages of this method:

- The dietary information tends to be less precise than that obtained in other methods. However it may be more representative of an individual's usual intake, than that derived from a detailed few days' food consumption.
- Some nutrients are more easily studied than others using this method and care must be taken when designing the questionnaire, keeping in mind nutrients of interest (Magkos and Yannakoulia, 2003).
- Nutrient intake estimates may be less precise than other methods.

2.3 Methodology of Dietary Assessment in Athletes

It is important to remember there are subtle methodological differences in the dietary assessment of athletes and non–athletes, which, when taken into account, may substantially increase the quality of intake data and optimise the outcome of dietary intervention (Magkos and Yannakoulia, 2003).

2.3.1 Number of Days Required

The number of days needed to obtain a reflective measure of 'habitual' dietary intake in an individual depends on the level of precision required (Black, 2001). If the aim is to examine the intake of a particular micronutrient in the diet e.g. Vitamin A then the recording period will need to be a lot longer than when merely looking at indicative overall energy intakes. Vitamin A is found in large amounts in only a small number of foods. Basiotis et al., (1987) reported that the typical amount of days required to accurately measure mean intake of vitamin A in males was 390 for males and 474 for females. The recording of dietary intake is usually done over a period of 1-7 days. A 1-day food record is not suitable for individual assessment because of the large intra–individual variability in daily food intake, but can be used in large groups of athletes as increasing the number of subjects surveyed decreases variability. A 3-day food record is considered the minimum requirement to indicate an individual's usual intake and one of the days should be a weekend day to reduce bias (Magkos and Yannakoulia, 2003, Basiotis et al., 1987). It is important to ensure that days of dietary monitoring accurately reflect usual food consumption during the period of investigation. In the case of jockeys it would be desirable to capture intake on both race and non-race days in order to accurately estimate habitual nutritional intake. A 7-day record unequivocally increases the resolution and reliability of collected data especially when intakes of individual athletes are being examined (Magkos and Yannakoulia, 2003). However this does also increase the burden on the respondent and may lead to reduced compliance or deliberate alteration to diet in order to simplify the recording process. (Magkos and Yannakoulia, 2003, Rutishauser, 2005). Rebro et al., (1998) found that 176 women reported a decreased nutrient and food intake on day 4 of a food record compared to day 1 of the same record, indicating a possible decrease in their ability to fill out the record rather than an actual decrease in food intake. A 3 to 4 day estimated diet record is the most widely used approach in athletes Deakin, (2010), however a collection of single or multiple diet recalls have also been shown to be commonly used (Magkos and Yannakoulia, 2003). When examining dietary intake in South African jockeys Labadarios et al., (1993) used a combination of dietary assessment methods: a '24 hour recall' at race meetings on two separate occasions; a 'seven day food record' and a 'Diet History'. This was done in an attempt to capture the erratic eating habits in this population.

2.3.2 Limitations of Dietary Assessment

In general, all methods measuring dietary intake are hampered by errors of precision (repeatability, reliability, reproducibility) and validity thereby restricting their accuracy (Black, 2001). It has long been recognised that dietary assessment tools are inaccurate in estimating habitual food intake, especially at the individual level with the bias being towards underestimation (Goris and Westerterp, 1999). Beaton (1994) suggests that dietary intake cannot be estimated without error and probably never will. Whilst acknowledging the limitations associated with dietary assessment, Rutishauser (2005) recommends that dietary data needs independent validation and that the nature of the errors need to be determined in order that they can be taken into account when evaluating the data.

There are two main types of errors; 1) random errors and 2) systematic errors. Random error increases the variance of the dietary estimates thus reducing their precision. An increase in the number of observations will see a decrease in the effects of random errors. For example, the effect of day-to-day variation in food intake can be reduced by increasing either the number of days of observation on each individual or the number of individuals for whom data are collected. In contrast the effects of systematic error cannot be reduced by increasing the number of observations. Systematic errors are errors that operate in one direction and consequently introduce bias into the results (Black, 2001). Systematic errors can distort data sets and produce mean intakes which are very high or low (Rutishauser, 2005). For example, use of inappropriate nutrient composition data for some food items but not others will affect the food intake data for different individuals in different ways (Black, 2001). Breakhuis et al., (2003) investigated the variability in estimation of self-reported dietary intake data from elite athletes when coded by a group of sports dietitians. Most reviews of dietary survey methodology consider that the greatest errors or limitations of dietary surveys lie with subjects and their inability to record an accurate and representative account of their habitual dietary patterns. Far less attention has been paid to the errors which can occur in the processing of food diaries to assess the reported intake of nutrients and energy. Possible sources of error or variability in the processing relate to inadequacies of food composition databases, as well as the variation in tasks completed by the person undertaking the analysis of the food diary (Rutishauser, 2005).

Undertaking a computerised dietary analysis involves a number of steps, which may all contribute to the error or variability component of results: reading and interpreting the food diary or survey instrument, selecting and entering the best – fit item from the available choices in the database, and quantifying the amount of each food or drink item. Highly trained sports dietitians were recruited to carry out the analysis. The results highlighted a number of interesting points; there was a large reduction (2-3 fold) in the variability in nutrient intake when the number of days of the food record was increased from 24 hours to 3 days and from 3 days to 7 days. There was substantial differences in the variability of various nutrients, with the more variable nutrients (e.g. vitamin C, vitamin A, cholesterol) having a 3 fold more variability than the least variable nutrients (e.g. energy, carbohydrate, magnesium). The authors emphasise that even when coder error is eliminated there are differences in variability in the intake of various nutrients (Braakhuis et al., 2003). This is in agreement with Marr and Heady (1986) who note that nutrients can be classified into three groups:

Category 1: nutrients consumed daily in a varied diet e.g. energy, carbohydrate, protein, fibre and fat. These nutrients are distributed widely in foods and are eaten quite regularly so they have low variability.

Category 2: includes nutrients such as calcium, types of fatty acids, riboflavin, thiamine, cholesterol, vitamin A, and vitamin C. These nutrients are distributed widely in foods in moderate amounts but are often found in a limited number of foods in very large amounts. Because it is possible for an individual to eat a large amount of a nutrient from a single food source on a single rather than a regular occasion (e.g. vitamin A from liver, β carotene from carrots), it is typical to see wide variation in intake from day to day.

Category 3: includes nutrients, such as alcohol, that are not consumed at all by some people.

Another interesting finding of the study by Braakhuis et al., (2003), was that there was an apparent difference in the variability of nutrient intake in different types of people and a greater day-day variation in nutrient intakes of athletes in weight-conscious sports compared with those involved in endurance sports, team sports, and power and skill sports (Braakhuis et al., 2003).

It is important to consider the sources of the coder error in the interpretation of the data collected from the food diaries. The dietitian is trained to compute the foods and drinks described in the diary to the items included in the database of the dietary analysis package however in doing so, this can add layers of error or variability. Most modern dietary analysis packages contain information about a large number of foods. There is systematic bias with regard to the types of foods excluded from food databases; these include meals or dishes of multiple ingredients (e.g. lasagne, casseroles, stir fries), ethnic foods and packaged and convenience foods especially in niche markets such as sports foods. Some databases do allow food nutrient composition and new foods to be added if this information is available from food labels and manufacturers. Differences can arise in professional interpretation of the food record especially when judging portion size. Errors can simply occur through misreading of the food record and through mistakes in entering data. Errors can also arise when entering a mixed dish not in the data base. The coder has several options for handling this entry, they can match it to a similar dish or enter the raw ingredients judged to contribute to the total nutritional profile or enter a commercial equivalent (Braakhuis et al., 2003).

In practical terms if the coder error could be removed from the estimates of dietary intake, the dietitian would be able to better interpret the reported dietary intake of an athlete or group of athletes because the range of the likely true values could be reduced by about one third. It is important to take into account the validity of the self-reported food intakes (Braakhuis et al., 2003).

2.3.3 Prevalence of Under Reporting

One of the main errors in dietary assessment is misreporting. Polusna et al., (2009) undertook a systematic review of 37 studies of misreporting of dietary intake in adults by 24 hour recalls or by estimated or weighed food records. The percentage of under-reporters was 30% and energy intake (EI) was underestimated by approximately 15%. Underreporting of usual EI includes both under-recording and under-eating. Under-recording may be due to participants not recording all items consumed during the study period or could be due to error in estimating portion size. Under-recording has been defined as a discrepancy between reported EI and measured energy expenditure (EE) without any change in body mass, with body mass (assumed to be) constant during the observation/reference period. Under-eating occurs when participants eat less than usual or less than required to maintain body mass, and is accompanied by a decline in body mass (Goris and Westerterp, 1999).

2.3.3.1 Determinants of Under Reporting

Polusna et al., (2009) found that BMI seemed to be the most consistent factor related to under-reporting. The probability that a subject will under-report generally increases with higher BMI. Out of 37 studies reviewed 12 of the studies found BMI a significant predictor of under-reporting however 4 studies did not support this observation. Both age and gender have been associated with energy under-reporting. Studies studying this found a higher proportion of low energy reporting (LER) among women and older subjects. Out of the 37 studies 5 found that lower socio-economic status and education was a predictor of underreporting. A higher level of underreporting was seen in smokers compared to non - smokers. Eating habits of respondents also influence misreporting. It would appear that the more a subject consumes the more difficult it is to report consumption accurately, this may be due to remembering more food or the larger the portions the more difficult it is to record accurately (Subar et al., 2003). Schwartz and Byrd Bredbenner (2006) carried out a study on university students in the U.S. and found that portion distortion seemed to affect the portion sizes selected by young adults for some foods. Respondent memory lapses can affect recall methods in two ways the respondent may fail to recall foods actually consumed (errors of omission) or may report foods that were not consumed during the recalled day (errors of commission) (Gibson, 2005). Schoeller (1995) sites the work of Madden et al., (1976) who stated that portion size tends to be underestimated when large and over-estimate when small, which leads to a “flat slope” between reported intake and observed intake and may be in part due to societal pressures to consume less. A study by Gibson (2005) reported that respondents differ in their ability to accurately estimate portion sizes visually. Such discrepancies vary with the type and size of food. Large errors may occur, for example, when estimating foods of high volume but low weight (Gittelsohn et al., 1994). Mac Diarmuid and Blundell (1998) reported that food items with negative health image (e.g. cakes, sweets, confectionary) are more likely to be under-reported, whereas those with positive health image (e.g. fruits and vegetables) are more likely to be over-reported. This also suggests that dietary fat is likely to be under-reported. Higher percentage of energy from fat and variability in number of meals per day were among the best predictors of under reporting in women and eating frequency was the best predictor of underreporting in men.

2.3.4 Validation of Dietary Assessment Methods

It is now widely recognised that in order to assess the validity of any dietary assessment including weighed records, it is necessary to compare the dietary data with one or more objective measures that reflect but are independent of food intake. The three measures most widely used as independent assessments of dietary intake are:

1. Urinary nitrogen as a marker of protein intake
2. Energy expenditure as measured by doubly labelled water (DLW) to compare with energy intake in weight stable individuals
3. EI/BMR ratio to identify ‘plausible’ records of food intake.

2.3.4.1 Urinary Nitrogen

Collection of a 24 hour urinary nitrogen excretion, when collected over a period of 8 days, can accurately assess habitual protein intake. However compliance can be poor and access to laboratory facilities is required. Nevertheless this can provide a practical and independent assessment of protein, potassium and sodium intake (Rutishauser, 2005, Poslusna et al., 2009).

2.3.4.2 Doubly Labelled Water (DLW).

The DLW technique is widely regarded as the gold standard for measuring EE under free-living conditions (Rutishauser, 2005). The method involves the subject consuming a dose of water enriched with the stable isotopes deuterium (^{2}H) and ^{18}O. Urine samples, (saliva or blood may also be used) are collected at baseline before administration of the dose and subsequently either daily or at the beginning and end of the measurement period. The urine samples are analysed to determine the rate of disappearance of each isotope from the body. The measurement period is usually 14 days in adults. EE calculated is then compared with the reported EI and the deviation is expressed as magnitude of misreporting (as a percentage of EE or as an absolute deviation in kilojoule or kilocalorie). The main advantage to this method is that it involves minimal inconvenience to the subject and does not in any way interfere with their normal every day activities. It has a high level of accuracy and precision. The DLW method gives a small overestimate of 2-3% when compared with whole body calorimetry (Rutishauser, 2005). The main disadvantage to the use of DLW is cost of the isotopes and access to sophisticated laboratory equipment for mass spectrometric analysis. Therefore it is not routinely used for validation of dietary intake data in respect of EI (Rutishauser, 2005).

2.3.4.3 EI/BMR Ratio (Goldberg cut off)

EI/BMR ratio has been used as an alternative approach in comparing EI from dietary studies with an independent estimate of 'expected' energy requirements. The relevant relationship in this case is:

Energy Intake: Basal Metabolic Rate = Energy Expenditure: Basal Metabolic Rate (physical activity level or PAL)

The principles of the Goldberg cut- off is that it calculates the confidence levels (cut- offs) that determine whether the mean reported EI is plausible as a valid measure of food intake even if chance has produced a dataset with a high proportion of genuinely low (or high) intake (Black, 2000). For a group, if the mean reported EI:BMR is below the lower 95% confidence limit for the specific study period and sample size, then this is an indication of bias towards underestimation of EI (Rutishauser, 2005). Polusna et al., (2009) go on to explain that the Goldberg cut-off technique has not always been fully understood or correctly applied. The sensitivity of the Goldberg cut-off was improved when subjects were assigned a more suitable PAL. The BMR for the Goldberg cut-off can be either measured using indirect calorimetry or estimated through predictive equations.

In summary, the standard food diary is the most commonly used method to assess individual dietary intake in both general and sporting populations however it is important to be aware of its limitations. Evidence suggests that individuals' self-reported energy intake frequently and substantially underestimate true energy intake (O'Loughlin et al., 2013). The following section will look at new novel methods of dietary assessment emerging through advanced technology.

2.4 New Sensing Technologies Used in Dietary Assessment

In view of the ever increasing number of studies highlighting the limitations associated with currently used dietary assessment methods Polusna et al., (2009); Goris & Westerterp (1999) it would seem a new dietary assessment tool is required, either as a stand-alone assessment measurement or one which works in tandem with an already existing methods. With the rapidly evolving technology sector, researchers have begun to develop such methods, involving technology and multimedia. Adaptations of technology have led to extensive changes in how dietary assessment is performed. The most common objective has been to reduce the costs of both the collection and processing of dietary intake information due to the amounts and complexity of data usually involved (Thompson et al., 2010). These new methods provide a real time method of capturing food consumption (e.g. photograph of food) that is speedy, flexible, and easily accessible at any time (Hongu et al., 2011). Thompson et al., (2010) outlines the advances made in data collection and processing used in the national cohort studies e.g. web based food frequency questionnaires (FFQ) and audio questions with touch screen answers (to aid those with poor literacy skills), while computers, portable digital assistants (PDA), web based programmes, video/audio recorders and smart phones with cameras have introduced new ways to perform dietary assessment (Hongu et al., 2011). Computerised processing of dietary data is now standard. For example the Automated Multiple Pass Method systems used in national nutrition surveys support automated coding of the responses. Thompson et al., (2010) explain how computers have even allowed for the blending of current methods. The need for new dietary assessment methods and technological intervention has been recognised and funded and developed by the National Institutes of Health in the USA.

Sun et al., (2010) describe a wearable electronic system developed for objective dietary assessment. The authors describe a new technology; comprising of a device containing a miniature camera, microphone, and several other sensors built into the SenseCam: a 3 megapixel sensor, temperature sensor, and a light, colour and intensity sensor. The camera can be worn on a lanyard around the neck (Figure 2.1). The device captures data that is immediately in front of the wearer and is then saved to an internal memory card. The data are transferred regularly to the dietitian's computer for further processing and analysis. It is designed to be almost completely passive to the subject, and thus hopefully not intrude on or alter the subjects eating activities (Sun et al., 2010). The device is comprised of two main components; the unit worn around the subject's neck and a data analysis software package installed in a computer at the dietitian's office. This device would greatly reduce workload for both the participant and the dietitian. Once the data are received on the dietitian's computer it is disassembled into individual types and the video portion of the data is automatically scanned for human faces, which are then blurred to prevent identification. Sun et al., (2010) also describe a unique method for portion size quantification; participants are asked to take pictures of their commonly-used plates and measure their diameters. They are provided with a chequered tablecloth for their dining table. When eating episodes occur in the participant's home, food portion size can be determined computationally when one of these references is present in food pictures. When eating outside the home lights on the device are used to project a dimensional referent into the field of view. Portion size can then be quantified against this reference point. Once portion size and food type is determined a software nutrient analysis package can be referenced to produce an accurate dietary report. Hongu et al., (2011) also suggest that technology based dietary assessment methods may reduce the cost of collecting data and the burden of recording foods eaten thus increasing compliance.

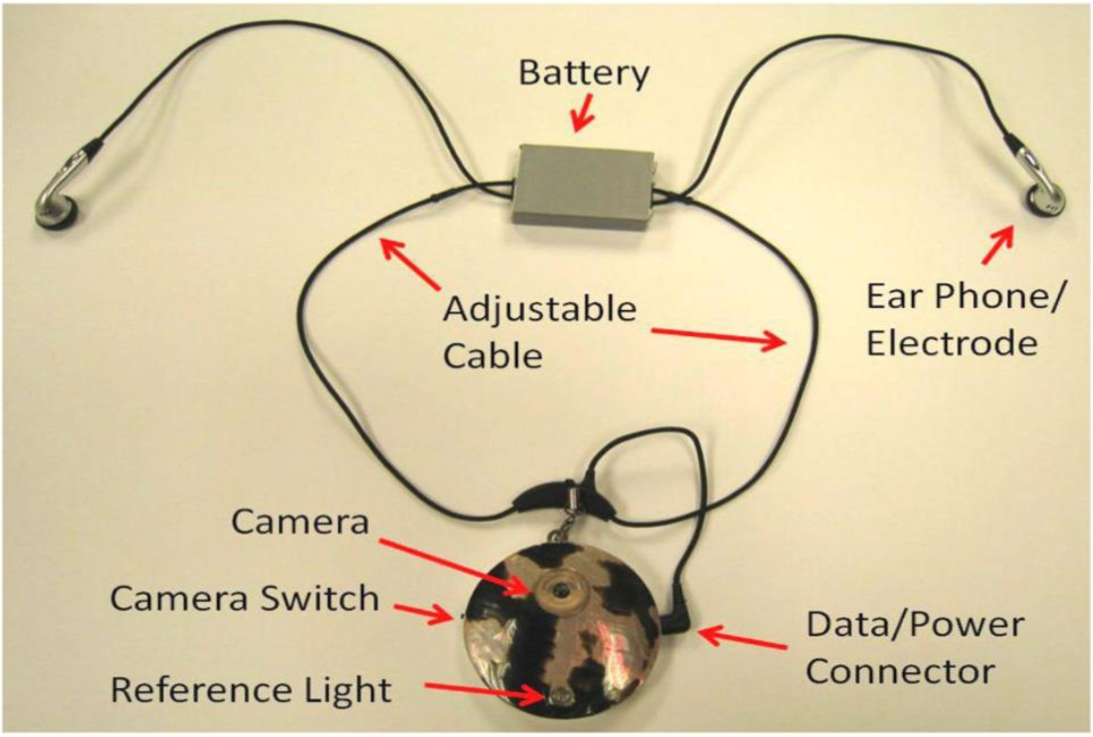


Figure 2.1 Wearable Electronic System for Objective Dietary Assessment (Sun et al., 2010)

Similar novel technologies are described by both (Higgins et al., 2009, Khanna et al., 2010). They claim that children and adults alike are keen to adopt new technologies. This is quite clear with the rising surge in smart phone and computer usage in all age groups in recent years. A recent consumer report in the USA reported that an estimated 75% of adolescents between the ages of 12 to 17 years have their own mobile phones, an increase of 30% over 6 years (Khanna et al., 2010). Kitamura et al., (2009) describe how taking a photograph of a meal before eating it may be used to improve dining habits and help people to lose weight. The availability of 'smart' phones with higher resolution imaging capability, improved memory capacity, network connectivity and faster processors allow these devices to be used in health care applications (Khanna et al., 2010). The authors, Khanna et al., (2010) also suggest that mobile telephones can provide a unique mechanism for collecting dietary information that reduces burden on record keepers. Furthermore, Six et al., (2010) state a dietary assessment application on a mobile telephone would be of value to dietitians and researchers. Brown et al., (2006) reported that dietary assessment methods amongst adolescents using a technology–based approach, namely a personal digital assistant (PDA) with or without a camera or a disposable camera, were preferred over the traditional paper food record. This suggests that for adolescents, dietary methods that incorporate new mobile technology may improve cooperation and accuracy. Khanna et al., (2010) provide an overview of a project being run at Purdue University called the Technology Assisted Dietary Assessment (TADA). They have developed a new system called the 'mobile telephone food record' (mpfr) application to provide an accurate account of daily food and nutrient intake. The developers goal was to use a mobile device with a built in camera, network connectivity, integrated image analysis and visualisation tools with a nutrient database, to allow the user to discretely record foods eaten (Khanna et al., 2010). Zhu et al., (2010) developed a prototype version of their new system on the iPhone for testing, not for commercial distribution, and it has been tested by dietitians and nutritionists in the Department of Foods and Nutrition at Purdue University for various adolescent and adult controlled diet studies. The authors describe how the system works; they have developed methods to automatically estimate the food consumed at a meal from images acquired using the mobile device. The system is designed so as it is easy to use and does not place a burden on the user by having to take multiple images, carry another device, or attaching other sensors to their mobile phones (Zhu et al., 2010). Each food item is segmented, identified, and its volume is estimated. "Before" and "after" meal images (figure 2.2) can be used to estimate the food intake (Zhu et al., 2010).

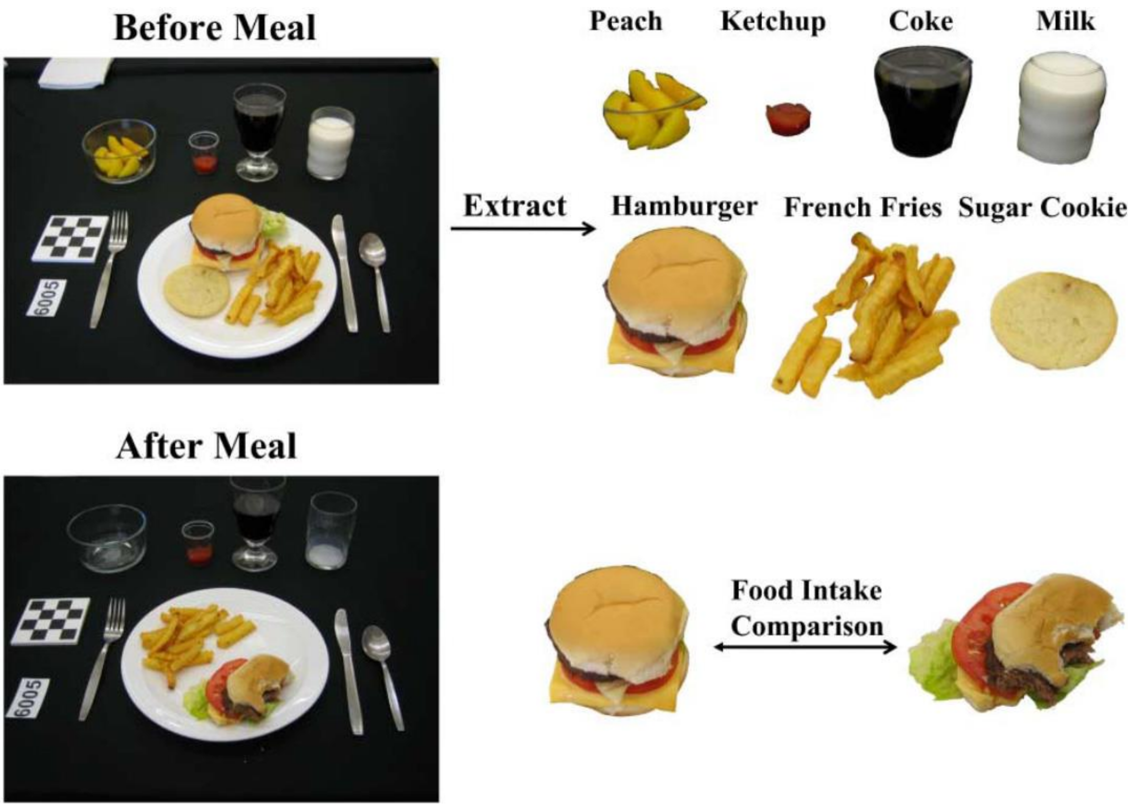


Figure 2.2 Food Image Analysis (Zhu et al., 2010)

The primary purpose of the study by Zhu et al., (2010) was to automatically determine the regions in an image where a particular food is located (segmentation) and correctly identify the food type based on its features (classification or food labelling). The authors provide a very detailed explanation of the methods for segmenting foods. With regards to identifying food features, Zhu et al., (2010) explain that two types of features are extracted and measured for each segmented food region; colour features and texture features. One of the challenging problems of image-based dietary assessment is the accurate estimation of food portion size from a single image. However the developers have devised a method to automatically estimate portion size of a variety of foods through volume estimation. These "portion volumes" utilize camera parameter estimation and model reconstruction to determine the volume of food items, from which nutritional content is then determined (Zhu et al., 2010).

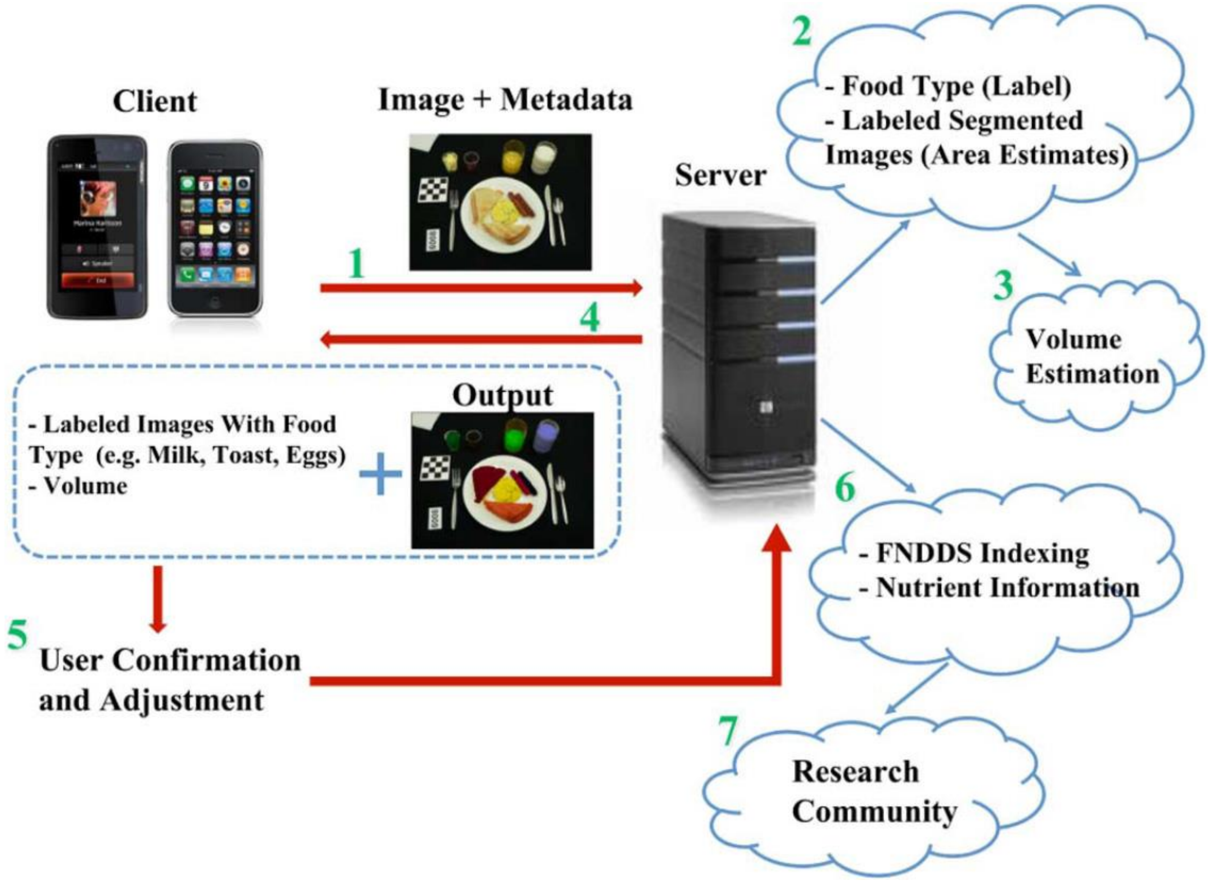


Figure 2.3 Client-server configuration (Zhu et al., 2010)

The authors describe two configurations for their system: a standalone configuration and a client-server configuration. The client server configuration (Figure 2.3) is explained; in most applications this will be the default mode of operation. The process starts with the user sending the image and metadata (e.g. date, time and perhaps GPS location information) to the server over the network (step 1) for food and volume estimation (step 2 and 3), the results of step 2 and 3 are sent back to the client where the user can confirm and/or adjust this information if necessary (step 4). Once the server obtains the user confirmation, food consumption information is stored in another database at the server, and is used for finding the nutrient information using the FNDDS database (USDA food and Nutrient Database for Dietary Studies, 3.0) (step 6). The FNDDS database contains the most commonly consumed foods in the U.S., their nutrient value, and weights for typical food portions. Finally these results can be sent to the dietitians and nutritionists in the research community or the user for further analysis (step 7). Interestingly, from a practicality perspective Zhu et al., (2010) describe an alternative mode of use other than taking meal time images. The other mode addresses the problem when no image is available. For some scenarios, it might be impossible for users to take meal images for example if they forget to bring their phone with them. The alternative method captures sufficient information for a dietitian to perform food and nutrient analysis, including date and time, food name, measure description, and the amount consumed.

Brown et al., (2006) devised a similar system in Georgia Institute of Technology. This system involved a camera, an exercise machine application and a desktop visualization application called Fotofit. Users take photos of snacks, meals drinks etc. They use their phone number to log into exercise machines in the gym which then sends a workout summary via text to the user. The desktop application allows users to use their food images and caloric information is automatically calculated.

To summarise a number of technology –based dietary assessment methods are currently being used to enhance accuracy and convenience of dietary assessment. The three major technology-based dietary assessment methods include (1) the use of the computer with or without the use of an internet application, (2) PDA, and (3) mobile phones with digital photo capability and/or Internet application capability (Hongu et al., 2011). Studies outlined by Zhu et al; (2010); Kitamura et al., (2009); Brown et al., (2006) all highlight the willingness of participants to embrace these new technologies. Their ease of use and accessibility may, however, still be in question.

A new sensing technology, the SenseCam, has been introduced by Microsoft with several possible applications across a broad spectrum of industries (Hodges et al., 2006a). To date, to the best of the researcher’s, knowledge the SenseCam's potential application to dietary assessment has not been investigated. This unique study uses SenseCam, to investigate whether it is a viable dietary assessment tool.

2.5 Importance of nutrition in relation to sports performance

2.5.1 Energy Balance and Energy Availability

Meeting energy needs is the first nutritional priority for athletes. Achieving energy balance is essential for maintenance of lean tissue mass, immune and reproductive function, and optimum athletic performance. In the field of dietetics, the concept of energy balance has been the usual basis for research and practice. In reflection of the importance played by nutrition to athletic performance the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine developed a joint position statement which was updated in 2009 and provides nutritional guidelines for athletes.

Energy balance is defined as dietary energy intake minus *total* energy expenditure (EB = EI – TEE). An imbalance between energy intake and energy expended will lead to alterations in body mass and body composition (Hall et al., 2012). Changes in body mass are a function of energy balance. Precise mechanisms exist to balance energy intake and energy expenditure to minimise fluctuations in body mass on a daily basis Harris, (2013) and to protect against adverse effects of negative energy balance (Nattiv et al., 2007). A complex interplay of endocrine signals that centrally influence appetite and satiety regulate the maintenance of energy homeostasis (Pasiokas et al., 2011).

In exercise physiology, the concept of energy availability recognizes that dietary energy is expended in several fundamental physiological processes, including cellular maintenance, thermoregulation, growth, reproduction, immunity and locomotion. Energy expended in one of these processes is not available for others. Energy availability is defined as dietary energy intake minus the energy expended in exercise (EA=EI-EEE) (Loucks et al., 2011b). As the amount of dietary energy remaining after exercise training for all other metabolic processes energy availability is an input *to* the body's physiological systems. Consumption of sufficient additional energy is further required by athletes in order to meet various training demands, maintain health, and if young, for optimal growth and development (Loucks et al., 2011b). Actual energy intake requirements depends on a variety of factors namely body composition, body mass, height, age, stage of development and level of fitness. In athletes the intensity, frequency and duration of the exercise activity must also be taken into consideration (American Dietetic Association, 2009). For healthy young adults , EB = 0 kcal.day $^{-1}$ when EA = 45 kcal.kg FFM $^{-1}$ .day^{-1} (where FFM=fat free mass) (Loucks et al., 2011b).

2.5.2 Macro and Micronutrient Requirements for Athletes

The current energy, nutrient and fluid recommendations are summarised in the position statement by the American Dietetic Association (2009). Carbohydrate recommendations for athletes range from 6-10g.kg^{-1} body mass per day. Sundgot-Borgen and Garthe (2011) recommend for weight category athletes, during times of energy restriction and weight loss to aim for 4-6g.kg^{-1}. This is to maintain blood glucose levels during exercise and replace muscle glycogen. Protein recommendations for endurance and strength-trained athletes range from 1.2-1.7 g.kg^{-1} body mass per day. Adequate protein is essential to maintain the immune system, preserve lean muscle mass and aid performance (ACSM et al., 2000). Sundgot-Borgen and Garthe (2011) recommend in weight category sports an increased level of protein to help preserve lean body mass, of 1.4-2.0 g.kg^{-1} while restricting energy intake. Philips and Van Loon (2011) go even further and recommend protein intakes of 1.8-2.7g.kg^{-1} and carbohydrate intakes of 3-4g.kg $^{-1}$ along with resistive exercise to optimize the ratio of fat-to-lean tissue mass loss during hypo-energetic periods. It is important to note that the aforementioned strategy will result in less absolute weight loss than if protein is not increased and resistive exercise is not performed (Phillips and van Loon, 2011a). The ADA recommend between 20-35% of energy from fat and that consuming ≤ 20% of energy from fat does not benefit performance (American Dietetic Association, 2009). Fat is a source of energy, fat soluble vitamins and essential fatty acids, and is an important component of an athlete's diet. High fat diets are not recommended. Sundgot-Borgen and Garthe (2011) recommend a lower amount of 15-20% fat during the weight loss period. Micronutrients play an important role in energy production, haemoglobin synthesis, and maintenance of bone health, adequate immune function and protection of the body against oxidative damage. Micronutrients assist with synthesis and repair of muscle tissue during recovery from exercise and injury. Elite athletes often have diets too low in energy and nutrients (Sundgot-Borgen and Garthe, 2011). With a lower than recommended intake of energy, carbohydrates and protein, deficits in micronutrients are common, may lead to nutrient deficiencies and adverse health effects (Sudi et al., 2004). This finding may have particular consequences for jockeys given the high risk nature of the sport (Hitchens et al., 2009, Waldron-Lynch et al., 2010).

2.5.3 The Effects of 'Making Weight' on Performance

There is no set of specific nutrition guidelines available which address weight-management issues for all weight-making sports. Sundgot-Borgen and Garthe (2011) have gone some way to recommending nutrient intake ‘norms’ during times of weight loss for weight category athletes. However not all weight category sports are the same, each has their own particular rules and specific constraints regarding weight divisions/restrictions (Walberg Rankin, 2010). It is important to take into account the period between weigh in and competition, time available to refuel plus the amount of times competitions occur throughout the year. It is well documented in a number of different weight category sports the effects of rapid reduction in body mass on athletic performance including; Judo Filaire et al., (2001), boxing Hall & Lane (2001), lightweight rowing Burge et al., (1993), wrestling Oppliger et al., (1996) and elite high intensity weight class sports (Sundgot-Borgen and Torstveit, 2004). Sundgot-Borgen & Garthe (2011) highlight that most studies on the effect of extreme weight loss have methodological weaknesses such as small samples, undefined performance level, unclear and uncontrolled diet and recovery regimes/strategies and questionable test parameters with regard to a specific performance test it is difficult to draw conclusions regarding the effect of extreme dieting on performance. However Filaire et al., (2001) demonstrated a negative physiological effect of a five percent reduction in body mass induced by seven days of food restriction in a group of judo players on a 30 but not seven second maximal jumping test. Burge et al., (1993) noted a 22 second decrease in maximal rowing time following a 5% loss of body mass within 24 hours. A more recent study by Slater et al., (2005) who investigated the effects of rapid weight loss on performance, also reported performance decrements in rowing time to exhaustion although the magnitude was much smaller than that reported by Burge et al., (1993). This performance decline was suggested to be due to the aggressive nutritional recovery strategies employed between weigh in and maximal performance testing in this study (Slater et al., 2005). Performance decrements were attributed mainly due to reduced plasma volume as a result of dehydration and a reduction in muscle glycogen.

The extent of the effects of rapid weight loss on performance seem to be related to the recovery strategy used between time of weigh in and competition. Unfortunately in the case of jockeys there is no time to refuel as weight is checked immediately before the race and immediately afterwards. Overall there appears to be evidence to suggest that extreme energy restriction (<30 $kcal.kg^{-1}$ FFM^{-1}) can affect muscle endurance and prolonged aerobic and anaerobic work capacity, which may impact on performance in weight classification sports of a high energy demand such as most combat sports and light weight rowing (Sundgot-Borgen and Garthe, 2011). In contrast, a study by Hall and Lane, (2001) investigating boxers revealed that boxing performance was shown to be unaffected by a 5% body mass loss in one week.

However subjective ratings of anger, fatigue, confusion and tension were demonstrated as being negatively affected in this study which is in agreement with the findings of other studies (Filaire et al., 2001, Horswill, 1993).

2.5.4 Weight cycling and Resting Metabolic Rate

In an effort to make weight continually throughout a season and without a strategic weight loss plan in place, the jockey can enter a pattern of continual weight cycling. Resting metabolic rate (RMR) appears to be disproportionately reduced when the body is in a state of energy deficiency and periods of prolonged underfeeding may be followed by rapid and disproportionately high replenishment of body adipose tissue stores (Deutz et al., 2000). In a study investigating female gymnasts, Deutz et al., (2000) found that percentage body fat was inversely correlated with the largest within-day calorie deficits, possibly due to an adaptive reduction in the resting energy expenditure. It has been suggested that weight cycling namely repeated phases of body mass loss and regain may enhance food efficiency in weight category athletes, by such mechanisms as a disproportionate decrease in RMR, so rendering weight loss and maintenance progressively more challenging (Brownell et al., 1987). Steen et al., (1988) examined RMR in adolescent wrestlers and found significantly lower RMR values in those who reported in engaging in repeated cycles of weight loss to 'make weight' followed by weight gain, to those who did not weight cycle. Despite this, however, a study in American collegiate wrestlers found that RMR values after a wrestling season were similar to pre-season and were higher than those of non-wrestlers (Melby et al., 1990).

2.5.5 Effects of 'Making Weight' on Bone Health

Low energy availability in female athletes causing a disruption to reproductive function and bone loss has been titled the "Female Athlete Triad". This Triad may have clinical manifestations including eating disorders, functional hypothalamic amenorrhea and osteoporosis (Nattiv et al., 2007). The Triad components have not been extensively studied or understood in male athletes, but in a study by Smathers et al., (2009) investigating a group of 32 trained male cyclists 25% and 9% were diagnosed with osteopenia and osteoporosis, respectively. Similarly Warrington et al., (2009) found that based on the WHO classifications, 53% of Flat and 10% of National Hunt jockeys showed whole-body osteopenia; 12% of Flat jockeys were osteoporotic. Interestingly, Labadarios et al., (1993) found that 31% of male and 44% of female jockeys omit dairy products from their diets in a belief that such foods are fattening, this may further add to the risk of developing osteopenia in this already compromised population.

2.5.6 Health Implications of Extreme Weight Loss

In addition to performance implications of making weight, weight loss practices taken to the extreme may have severe implications on health. Excessive dehydration, in an attempt to achieve rapid weight loss in order to make competition weight, has been implicated in the deaths of three American collegiate wrestlers (Dolan, 2010). It has also been suggested that excessive weight control and dehydration were responsible for the deaths of two young American jockeys, one of whom collapsed after a race due to severe dehydration Scheinemann, (2005), the other who was said to suffer a fatal heart arrhythmia caused by a potassium deficiency developed through chronic weight control and energy restriction (Scheinemann, 2005, Finley, 2005). Similarly, judo medallist was reported to have died of a heart attack probably triggered by an extreme, rapid weight-loss regimen while preparing for the 1996 Atlanta Olympic Games (Sundgot-Borgen and Garthe, 2011).

A less aggressive method of weight loss is recommended by ACSM, (2000) aiming for a 0.5-1kg weight loss per week by introducing an energy deficit of 3500-7000 kcals /week. Gradual weight loss seems to be the method with least impairment of performance to athletes. In fact studies indicate that some athletes may even improve performance during weight loss when using a gradual approach Folgelholm et al., (1993) and can increase lean body mass (Garthe et al., 2009).

2.6 Summary

The review of literature demonstrates that with no precise strategy for managing or achieving the stipulated low body mass required for racing, chronic energy deficiency and dehydration are common in this population. Restricted fluid intake, along with active and passive dehydrating practices appear to be the most commonly employed methods used by weight category athletes in an attempt to make weight for competition. Results from previous studies with jockeys reveal worrying trends among this population, who tend to have low bone mineral density, low percentages of body fat, poor hydration practices and a high incidence of racing-related injury (Leydon and Wall, 2002, Labadarios et al., 1993, Warrington et al., 2009).

The negative effects of these weight making practices may be exacerbated in Jockeys due to the length and intensity of the racing season. There are limited data available regarding the dietary practices of jockeys as a group. In this context this research study will further investigate the dietary practices of professional Irish Jockeys and review and trial new dietary assessment tools available by which to more accurately access dietary intake within this group.

Chapter 3: An Analysis of Nutritional Practices of Professional Irish Jockeys

3.1 Abstract

Background: Horse racing is a highly competitive and high risk sport that requires jockeys to have strength, balance and cardiovascular fitness whilst also possessing the ability to maintain high levels of concentration. Horse Racing is a weight category sport and jockeys face enormous pressure to make and maintain a low body mass in order to compete at the stipulated weight assigned to their particular horse which may vary from race to race. Failure to do so can result in fines and suspensions or simply missing races and thereby losing riding opportunities. Despite the popularity of this sport there is little scientific research relating to the dietary habits and practices of professional jockeys. **Aim:** The aim of this study was to examine the dietary practices of 18 professional jockeys using a 7-day food diary. **Methods:** Eighteen male Caucasian jockeys (11 Flat and 7 National hunt) aged 27.3 ± 6.8 years, completed a 7-day food diary, as part of a larger study which also investigated lifestyle and weight control practices of professional jockeys. Anthropometric data including height and body mass were measured, along with lean and fat mass which were evaluated using a whole body DXA scan. **Results:** Energy intake was similar for Flat (1699±436 kcal) and National Hunt (2013±707 kcal) jockeys. The total energy intake in both groups was low and appeared to provide insufficient availability of energy for sustainment of usual daily and metabolic processes. Carbohydrate intake (3.7±1.3g.kg^{-1}) was below recommendations for athletes, whilst protein levels (1.3 ± 0.5. kg $^{-1}$) were within recommended amounts for athletes in general, the levels fell short of the recommendations for athletes par-taking in weight category sports. Overall fat intake was high in both groups at 32% and 34% of energy for Flat and National Hunt respectively, both above the recommendation for athletes competing in weight category sports. The relative contributions from fatty acids were 13.5%, 11.2% and 4.4% for saturated, monounsaturated and polyunsaturated respectively. Alcohol intake varied widely across the sample (0-17% energy or 0-58.8g .day^{-1}) A substantial proportion of jockeys failed to meet the estimated mean requirement and lower threshold intake for a number of micronutrients. Jockeys consumed well below (0-2) the recommended five daily servings of fruit and vegetables set by the World Health Organization. **Conclusions:** While a level of under reporting cannot be ruled out, overall the results of this study indicate that the current nutritional practices of professional jockeys are sub-optimal and may expose them to longer term health risks.

3.2 Introduction

Horse racing is a weight category sport, which necessitates jockeys to maintain a strict body mass in order to compete. Weight allocations or "handicapping" are based on the ability of the horse and are designed to maximise competitiveness of each race. The need to continuously align body mass with racing limits appears to encourage the use of short-term and potentially dangerous acute weight loss strategies, such as exercising in sweat suits, sitting in saunas for lengthy periods and energy and fluid restriction, in an attempt by jockeys to optimize riding opportunities (Hill and O'Connor, 1998, King and Mezey, 1987, Moore et al., 2002). The weight restrictions imposed on jockeys have been described by many commentators as archaic, arbitrary and potentially dangerous (McGrath, 2006). Weight allocations in Irish horse-racing currently range from 52.7 to 64.0 kg and 62.0 – 76.0 kg for Flat and National Hunt jockeys respectively. Jockeys must weigh in fully clothed, wearing riding boots, back protector, and carrying their saddle. Since 1978, the mean weight of apprentice jockeys has increased by approximately 47%, but in that period the minimum weight for a flat jockey has risen by only 10%. The acute weight loss methods currently employed by jockeys appear to be based on tradition and passed on from peers rather than being based on sound scientific principles (Leydon and Wall, 2002, Warrington et al., 2009). The constant reliance on unhealthy weight making practices in jockeys has been reported in a number of studies (Dolan et al., 2011b, Labadarios et al., 1993, Leydon and Wall, 2002, Moore et al., 2002). In order to provide appropriate nutritional advice it is necessary to firstly establish the jockey's habitual intake.

Aim:

The aim of this study was to evaluate the dietary practices and examine the nutritional adequacy of the diets of professional Irish Jockeys.

Objectives:

To analyse the dietary intake of a group of professional Irish Jockeys, using a 7-day food diary.

To evaluate differences between the dietary intake of professional flat and national hunt jockeys.

Hypothesis:

Jockeys have habitually low energy intakes which are not aligned to the recommended dietary guidelines for weight category athletes.

There is a significant difference between the dietary intake of professional flat and national hunt jockeys.

3.3 Methodology

3.3.1 Research Design Overview:

Twenty seven male professional jockeys (17 Flat and 10 National Hunt) took part in a study designed to assess their nutritional, lifestyle and weight control practices. Of the twenty seven participants eighteen completed a seven day food diary over a typical racing week, eleven of the jockeys failed to complete and return a food diary. Dietary intake was assessed through the use of the traditional seven day food diary. The food diaries were analysed (using a validated dietary analysis package, Windiets Nutritional Analysis Software (Robert Gordon University, Aberdeen, Scotland) for macro and micronutrient intake and compared to the recommendations for athletes and the WHO/FAO guidelines.

3.3.2 Participants

The 27 participants were initially recruited through widespread advertisement at Irish race tracks to take part in this study. Of the twenty seven recruited (17 Flat and 10 National Hunt), eighteen (11 Flat and 7 National Hunt) completed a 7-day food diary. All participants provided written informed consent and ethical approval was granted by the Irish Turf Club's Medical Committee before the study began. Participants were restricted to male professional jockeys who held a current licence.

3.3.3 Research Tools

3.3.3.1 Food Diary

Each participant was met by a professional Dietitian and provided with a standard 7-day food diary to complete. The diary detailed full instructions on completing the diary as accurately as possible. For this particular method the participant recorded all foods and fluids and the amounts over 7 days. The amounts consumed were measured in household measures (such as cups, tablespoons) or estimated using models and pictures. Participants were required to document the time at which foods was consumed in addition to the food, brand name, and quantity (e.g. Yoplait full fat strawberry yoghurt 125g). Helpful hints were given in the diary along with examples of ready prepared meals and take away meals. For example, if cheese was consumed subjects were prompted to include what type of cheese whether it was soft or hard and regular verses low fat. If chicken was consumed, subjects were asked to specify if it was leg, wing and/or breast or white meat only, and whether the skin was eaten or not. The participants were asked to keep the 7-day food diary over a typical racing week. The use of a food frequency questionnaire was considered however due to the small sample size the 7 – day food diary was considered more appropriate. It also enabled the dietitian to provided individual feedback to the Jockey in order to assist him in making weight.

3.3.3.2 Dietary Analysis

The same dietitian individually reviewed the diaries with each jockey for detail and completeness. The diaries were coded and any ambiguities resolved with the participants prior to computer analysis using Windiets food database for Windows (http://www.rgu.ac.uk/**windiets**). Windiets consists of 13378 UK food labels, 336 supplements and 1603 restaurant items plus 44,008 international foods to help with ethnic diets. Researchers can pick foods from a list and enter their weights. An option to add local foods is also available if not already listed. If foods were not listed in the data base the option to add a local food was used and the nutritional information entered into the database.

3.3.4 Anthropometric and Body Composition Measures

Body mass was measured while wearing minimum clothing and reported to the nearest 100g using a portable digital scale (Salter, Germany). Stretch stature was measured to the nearest millimetre using a portable stadiometer (Seca, Leicester Height Measure).

3.3.4.1 Dual Energy X-Ray Absorptiometry (DXA)

Dexa is now widely accepted as a standard technique for measuring body composition (Haarbo et al., 1991). Lean and fat mass were measured using a total body DXA scan (Lunar Prodigy Advance Scanner, GE Medical Systems, UK), as previously described by (Warrington et al., 2009) (Figure 3.1). Positioning for all scans was completed in accordance with manufacturer instructions. For the total body scan participants were centred and squared in the centre of the table with ankles and knees taped together and scanner laser light positioned approximately 3cm above the head. Lumbar spine scans were taken from L5 – T12. Legs were positioned upright on the provided foam block to lessen curvature of the spine. Scanner laser lights were positioned midway between the iliac crest and ASIS along the midline of the body. Femoral neck was measured after placing the hips in an internally rotated position and positioning the laser light five - six cm below the greater trochanter along the mid line of the thigh. The relative contributions of fat and lean mass were extrapolated from the results of the total body scan.

Figure 3.1 GE Lunar Prodigy Advance DXA Scanner

3.3.5 Statistical Analysis

A quantitative approach was used to analyse the nutritional data. Quantitative data analysis was carried out using SPSS for windows (SPSS Inc., USA). Parametric tests of difference (i.e. independent sample t-tests) were used to compare the nutrient intakes of the Flat and National Hunt jockeys. Statistical significance was set at $P<0.05$. Data are reported at a means ± standard deviations (*SD*).

3.4 Results

3.4.1 Descriptive Data

Descriptive data for all subjects are presented in Table 3.1.

Table 3.1 Anthropometric characteristics of Irish Flat and National Hunt jockeys

	Total **n=27**	**Flat** **n=17**	**National Hunt** **n=10**
Age (yrs)	27.3 ± 6.8	26.7 ± 7.6	28.3 ± 5.3
Height (m)	1.67 ± 0.1	1.6 ± 0.1	1.73 ± 0.1 **
Body Mass (kg)	58 ± 7.4	53.1 ± 4.1	66.2 ± 2.9 **
BMI (kg/m^2)	20.7 ± 1.5	19.9 ± 1.3	22.1 ± 0.8 **
% Body Fat (DEXA)	9.5 ± 3.1	9 ± 2.5	10.4 ± 4

Data presented as mean ± SD (*p<0.05; ** p<0.01)

3.4.2 Dietary analysis

Energy intake was similar in both groups with no significant differences observed between Flat (1699 ±436 kcal) and National Hunt (2013 ±707 kcal) jockeys (Table3.2). When energy intake per Kg was compared between the Jump and Flat jockeys it showed similar results; mean energy intake for flat jockeys was 32kcal/kgBW and 30 kcal/kgBW for National Hunt jockeys. Energy intake/LBM (by DEXA) was 33.5kcal/LBM for the Flat jockeys and 40.5 kcal/kgLBM for the National Hunt Jockeys. Mean estimated resting metabolic rate was 1479 ± 124 kcal/d^{-1} (Flat: 1393 ± 47 kcal.day$^{-1;}$ National Hunt: 1614 ± 71 kcal.day^{-1}). Mean energy intake was theoretically sufficient to support a physical activity level of (PAL) of 1.22 ± 0.36, approximately 22% above resting metabolic rate (Flat 1.2 ± 0.3; National Hunt: 1614 ± 0.45). The group of jockeys who completed the food diaries displayed a mean lean mass 49.7 ± 6.2 kg. Alcohol consumption varied widely across the sample (0-17% of energy or 0 - 58.8g. day^{-1}). Being that the energy intakes of the Flat and National Hunt jockeys were similar and not statistically different the data for both groups were pooled for further analysis. The relative contributions of fatty acids were 13.5%, 11.2% and 4.4% for saturated, monounsaturated and polyunsaturated respectively. Relative to body mass, the Flat and National hunt jockeys consumed 3.7 ± 1.3 g.

kg $^{-1}$ and 1.3 ± 0.5 g.kg $^{-1}$ of carbohydrate and protein respectively, which again was not significantly different between Flat and National Hunt.

Micronutrient intake is summarized in (Table 3.2). A substantial proportion (> 50%) of the subjects consumed less than the recommended daily amounts (RDA) for the following nutrients: Vitamins A (83%), folate (83%), vitamin C (72%), riboflavin (72%), Zinc (66%), and calcium (61%). Of greater concern was the proportion consuming less than the lower threshold of; folate (55%), Vitamin C (38%), Vitamin A (27%), Calcium (11%), riboflavin, Iron and Selenium (5% each). A substantial proportion of the sample failed to meet the recommended daily allowance for most nutrients (Table 3.2). Participants consumed a mean of 0.9 ± 0.8 servings of fruit and vegetable per day (range 0 – 2) and 2 ± 0.5 fast food/takeaway meals per week (range 0-5) with no differences between Flat and National Hunt jockeys.

Table 3.2 Intakes of macronutrients in Irish Flat and National Hunt Jockeys

	Total n = 18	**Flat n = 11**	**National Hunt n = 7**	**Recommended Intake**	**For making weight**
Energy kJ	7576 ± 2370	7012 ± 1824	8462 ± 2979		
(kcal)	1803 ± 564	1669 ± 436	2013 ± 707		
CHO (g)	210.6 ± 72.1	201.1 ± 52.2	225.4 ± 99	-	
% of Energy	44	45	42		
g·kg^{-1}	3.7 ± 1.3	3.9 ± 1.1	3.4 ± 1.6	6 – 10	4 - 6
Protein (g)	75 ± 29.3	65.3± 19.6	90.3 ± 36.5	-	
% of Energy	17	16	18		
g·kg^{-1}	1.3 ± 0.5	1.3 ± 0.4	1.4 ± 0.6	1.2 – 1.7	1.4 - 2.0
Fat (g)	67.7 ± 24.1	62.5 ± 24.2	76 ± 23.1		
% of Energy	33	32	34	20 – 35	15 - 20
Alcohol (g)	12.3 ± 12.7	12.7 ± 14.2	17.5 ± 17.3		
% of Energy	5	5	6	*	

Note: Recommended intakes taken from (American Dietetic Association, 2009). Recommended for making weight taken from (Sundgot-Borgen and Garthe, 2011) *Irish recommended alcohol intakes are ≤210g.week^{-1} with no more than 40g.day^{-1} (Morgan et al., 2009).

Table 3.3 Intakes of Micronutrients of Irish Flat and National Hunt Jockeys

Nutrient	Reported Intake	n (%) ≤ LTI	N(%) ≤ EAR	n(%) ≤ RDA
Vitamin A ug)	498 ± 335	5 (27 %)	15 (83%)	16 (88%))
Thiamine (ug)	1.2 ± 0.3	0 (0%)	1 (5%)	7 (38%)
Riboflavin (mg)	1.1 ± 0.4	1 (5%)	13 (72%)	16 (88%)
Niacin (mg)	44.2 ± 34.5	0 (0%)	0 (0%)	0 (0%)
Vitamin B6 (ug)	1.7 ± 0.5	-	-	16 (88%)
Folate (ug)	166 ± 59	10 (55%)	15 (83%)	18 (100%)
Vitamin B12 (ug)	2.7 ± 1.4	0 (0%)	3 (16%)	3 (16%)
Vitamin C (mg)	67 ± 75	7 (38%)	13 (72%)	13 (72%)
Vitamin D (ug)	1.5 ± 0.8	-	-	18 (100%)
Calcium(mg)	619 ± 295	2 (11%)	11 (61%)	16 (88%)
Phosphorus (mg)	1160 ± 594	0 (0%)	1 (5%)	1 (5%)
Iron (mg)	10.5 ± 6.4	1 (5%)	8 (44%)	11 (61%)
Zinc (mg)	7.2 ± 2.3	2 (11%)	12 (66%)	14 (77%)
Selenium (ug)	42.6 ± 11.9	1 (5%)	6 (33%)	17 (94%)
NSP (g)	9.3±3.2	**-**	**-**	18 – 25

Note: Recommended vitamin D intakes taken from Cashman et al. (2008). LTI¼lower threshold intake, EAR = estimated average requirement, RDA = recommended daily allowance. % < LTI, EAR, and RDA (Food Safety Authority of Ireland, 1999) refers to the percentage of participants not meeting these intakes (it should be noted that not all of the vitamin D requirement will be met through diet, alone a certain amount will be obtained from sunlight) LTI and EAR information was not available for vitamin B6, vitamin D or non-starch polysaccharides. The RDA for non-starch polysaccharides taken from Whitehead et al., (1991).

3.5 Discussion

The aim of this study was to examine the diet of professional jockeys over a typical racing week. The results suggest that jockeys' typical dietary intake is low in energy and inadequate in a number key macro and micronutrients. In addition, acute weight loss strategies often employed by jockeys such as fasting, dehydrating through sweating and excessive exercise and in some cases forced vomiting further compound the problem (Wilson et al., 2013, Leydon and Wall, 2002, Warrington et al., 2009). The ADA (2009) outline the importance of meeting energy and macronutrient needs during times of high physical activity in order to maintain weight, replenish glycogen stores and provide adequate protein to build and repair tissue. They recommend sufficient fat (20 – 35 % of total energy intake) to provide the essential fatty acids and fat soluble vitamins, as well as contribute energy for weight maintenance. Total energy intake in this study was low, with participants taking in only 1.2 times the resting metabolic rate (1492±114) which is the equivalent to the maintenance of the metabolic needs of men during bed rest (Manore and Thompson, 2006) and not a professional jockey with an active lifestyle. In addition, it must be noted that the equation used to estimate resting metabolic rate Mifflin et al., (1990) was developed based on normal weight and obese individuals, which means it is likely to overestimate the RMR of a jockey. Race day total energy expenditure has previously been estimated to be 3952 ± 577 kcal.d^{-1} Dolan et al., (2008) suggesting a mean race-day energy availability of 0.8 ± 12 kcal.kg LBM $^{-1}$. day $^{-1}$ (LBM = lean body mass). Macronutrient distribution was 44% carbohydrate, 17% protein, 33% fat and 5% alcohol and was similar for Flat and National Hunt jockeys. As there was no significant difference between intakes of the Flat and National Hunt jockeys the data was pooled.

Energy intake from alcohol was high (5%) relative to the low total energy intake reported. Alcohol intake varied widely across the sample (0-17% of energy or 0-58.8g.day $^{-1}$). Due to the low total daily energy intake, intake was still within the Irish public health guidelines for males Analysis showed that only one of the jockeys exceeded the national health recommendations (≤210g.week^{-1} with no more than 40g.day^{-1}) (Morgan et al., 2009). Alcohol has little nutritional value and may impair rehydration and glycogen storage after exercise (Burke, 2006). Regular intake is undesirable for athletic populations and particularly those following a weight and energy restricted lifestyle.

As energy deficiency and weight cycling has been suggested to have a suppressive effect on resting metabolic rate (Deutz et al., 2000), it is possible that this may have caused an overestimation of resting metabolic rate in this group. Future studies are required to further investigate this theory by measuring RMR using indirect calorimetry in this population.

Unfortunately energy expenditure of the jockeys was not measured in this study therefore it is not possible to accurately calculate energy availability. However it is likely that energy availability is an issue in this group. Loucks et al., (2011a) recommend that athletes follow a diet and exercise regimen that provide energy availabilities of 30-45 kcal.kg FFM $^{-1}$ while training to reduce body size. A lower energy expenditure and potentially increased energy intake on non-race days (up to 4 days per week) may partially but probably not completely compensate for this deficit in energy availability. In some cases energy expenditure may actually be higher on a non-race day due to additional physical demanding activities such as riding out and manual work such as 'mucking out' stables. A recent study by Wilson et al., (2012) reported estimated energy expenditure (EEE) in professional jockeys on a non-race day to be between 2269 and 3296 kcals.d $^{-1}$ while the estimated energy intake (EI) was found to be between 1361 – 1958 kcals.d^{-1}. The discrepancy between the reported energy intake and expenditure reflecting an energy deficit could also in part be explained by a potential under reporting of EEI which is common when using food diaries (Poslusna et al., 2009).

Leydon & Wall, (2002) reported that as a group jockeys diminish their dietary intake in the short term, namely the day before a race and then make up for it in the long term on non-race days. This practice of weight cycling, can lead to an unhealthy eating pattern with the possible risk of slipping into a state of disordered eating (Sundgot-Borgen and Garthe, 2011). Similarly, Moore et al., (2002) investigating the dietary practices of jockeys, reported 33% of the jockeys they studied skipped at least on meal a day and those jockeys who found it most difficult to make weight were the more likely to report that they skipped meals.

A very low energy intake coupled with the extreme weight making practices places the jockey at risk of a number of nutritional deficiencies and negative health effects. Reduced carbohydrate intake can result in glycogen depletion, fatigue and inadequate recovery between race days (Burke et al., 2004). A reduced protein intake will result in a greater loss of lean tissue during weight loss, Mettler et al., (2010) which may lead to a reduced RMR and will alter the prescription for weight loss (Walberg Rankin, 2010). During weight loss there is also an increased risk of suboptimal intake of calcium and Iron and other micronutrients (Fogelholm et al., 1993). Although this may not cause a problem initially, the requirement to make weight continuously throughout the course of an extended racing season and the ongoing need to maintain body mass within strict limits may lead to compromised vitamin and mineral status in this population (Warrington et al., 2009). Carbohydrate intake (3.5 ±1.5) failed to meet the recommended intake of 6 g. kg^{-1} American Dietetic Association, (2009) nor did it meet the lower amount of 4 g. kg $^{-1}$ recommended for making weight (Sundgot-Borgen and Garthe, 2011). These results were similar to an earlier study investigating New Zealand jockeys Leydon & Wall, (2002) which reported a mean intake of 3.4 $g.kg^{-1}$ carbohydrate. Mean protein intake for the participants in the present study was 1.3 ± 0.5 g.kg $^{-1}$ and did reach the recommended 1.2g.kg $^{-1}$ recommended by the ADA American Dietetic Association, (2009) however protein requirements may be increased in energy deficient athletes and was below the recommended 1.4g.kg $^{-1}$ -2.7g.kg^{-1} for making weight (Sundgot-Borgen and Garthe, 2011, Tarnapolsky, 2006, Phillips and Van Loon, 2011b). Currently there are no specific dietary guidelines for jockeys as the specific physiological demands of horse racing have yet to be identified but the limited data available would suggest a typically chronic state of energy deficiency in this group (Dolan et al., 2011b). Although some degree of misreporting can be expected as food diaries are prone to underestimation Poslusna et al., (2009) knowledge of the making-weight lifestyle of jockeys and the need to chronically maintain a low body mass is consistent with the observed low energy intake reported in this study. Similar results have previously been reported in jockeys by Labadarios et al (1993); Leydon & Wall (2002); Moore et al (2002); Wilson et al., (2013) and Cotugna et al., (2010), although this is the first study to report typical intake relative to lean body mass and to consider the likely energy availability of jockeys. This dietary analysis in this study provides a greater depth of understanding of the degree of energy deficiency experienced by jockeys and shows that the poor dietary intakes previously reported by Labadarios et al., (1993); Leydon & Wall (2002) and Moore et al., (2002) remain prevalent in jockeys today. Due to their restricted energy intakes Jockeys have a very small calorie window in which to achieve their nutrient intake goals however close examination of the food choices in the present sample indicated a strong reliance on processed and convenience foods that tend to be energy dense high in fat, sugar and salt and low in fibre and micronutrients. Participants reported taking a mean of two fast food/takeaway meals per week. This may due to a lack of nutritional knowledge, and cooking skills. Labadarios et al., (1993) found a poor level of nutritional knowledge in the group of jockeys studied. It may also be due to lack of appropriate provision of food at many of the racetracks. Jockeys reported attending 3 ± 1 race meetings per week. ‘Wasting’ on race days prior to racing was common with a tendency towards eating take-away foods after racing had finished. A low intake of fresh produce, in particular fresh fruit and vegetables, was observed (mean 0.9 servings a day; range 0-2), which is surprising as these foods are low in energy and nutrient rich, suitable for energy restricted diets. No jockey met the recommended intake of portions of fruit/vegetables per day.

Other possible consequences of low energy availability include impaired bone health. As energy availability declines, the rate of bone protein synthesis declines along with insulin, which enhances amino acid uptake, in a linear dose response manner. The rate of bone mineralization declines abruptly as energy availability declines below 30 kcal.kg FFM $^{-1}$. Decreased concentrations of Insulin like growth factor and-1 and tri-iodythronine have also been seen. These effects occurred within 5 days of the onset of energy deficiency (Ihle and Loucks, 2004). This has worrying implications with regards to jockeys when combined with the low calcium and vitamin D intake seen in the present study with 88% of the jockeys failing to meet the RDA for calcium and none of them meeting the RDA for Vitamin D (even though some Vitamin D will be obtained from sunlight). Furthermore, no participant in this study reported taking the recommended five portions of fruit and vegetables per day with a mean of 0.9 ± 0.8 (range 0-2). Inadequate intake of fruit and vegetables may affect bone mass in one of two ways: 1) they are abundant in bone promoting vitamins and minerals and 2) fruits and vegetables are alkaline and act as a neutralising buffer to the human body. In addition the high level of smoking (57% current or past smokers) and high alcohol consumption (5% of mean total energy intake), reported in the present study, are likely key contributory risk factors to compromised bone health. It is therefore not surprising that Warrington et al., (2009) previously reported low levels of bone mineral density in this particular population.

Mean micronutrient intake was also found to be inadequate with greater than 50% of the sample failing to meet the mean requirement for Vitamins A, C, riboflavin, folate, calcium and zinc. It is important to note that to accurately access dietary vitamin intake a longer period than 7 days recording would be required (Braakhuis et al., 2003). However it does provide an indication that the intake is well below the recommended guideline.

3.6 Limitations

A number of limitations are present within this study which may have affected interpretation of results and merit consideration. Food diaries, while the most commonly used method of dietary assessment due to their non–invasive nature and ease of use are known to be inaccurate and participants may under-estimate, under-record and possibly under-eat when keeping the diary (Black, 2000). Intake of all micronutrients cannot be accurately assessed in only 7 days and biochemical analysis of blood or tissue may be required to determine if a deficiency exists. Due to logistical and methodological issues, the sample size in this study was small, however it did represent over 10% of the professional jockey population registered in Ireland. By further increasing the number of observations would decrease the impact of random errors. Coder error must also be considered, as jockeys rely heavily on convenience foods and take-away foods it may be difficult to analyse these foods accurately and estimate and use of comparison foods may be used in place of exact dietary composition. The small sample size also means that the results are not representative of all Irish Jockeys. The food diaries were kept over 7 days this may have caused user fatigue leading to possible under-reporting. To accurately assess nutrient intakes of certain micronutrients e.g. Vitamin A, a longer period of recording would be required.

3.7 Conclusion

Despite the limitations outlined above, these results support previous research that professional jockeys similar to athletes in other weight making sports are at increased risk of inadequate dietary intake and may use extreme weight management strategies to comply with stipulated weight limits (Labadarios et al., 1993, Leydon and Wall, 2002, Moore et al., 2002). Current circumstances present a challenge for jockeys and the horse-racing industry. Many jockeys' careers and financial security depend on taking 'lighter rides' (i.e. those mounts who have been given the lightest weight allocation) and accepting these with minimal notice (i.e. 24 hours is typical notice given to jockeys). It is the responsibility of the racing authorities to ensure that appropriate food provision is offered at the racetracks to allow jockeys the opportunity to refuel in accordance with current dietary guidelines outlined by the American Dietetic Association (American Dietetic Association, 2009). A more flexible and scientifically validated handicapping system may be required in order to reduce the strain placed upon these athletes along with an individualised minimum weight structure for apprentice jockeys. Further research is required to determine specific energy demands of horse racing so that specific dietary guidelines can be developed for jockeys.

Chapter Four: A comparison and validation of dietary analysis of a standard one day food diary and the SenseCam in three different populations.

4.1 Abstract

Background: Food diaries are commonly used to assess individual dietary intake in both the general and sporting populations. Despite the widespread use of such diaries, evidence suggests that self-reported energy intake may frequently and substantially underestimate true energy intake. A previous study Dolan et al., (2011b) which undertook dietary evaluation of 18 Professional Irish Jockeys using a standardized 7-day food diary, results suggested that a level of under-reporting was present. **Aim:** To examine the effectiveness of the use of a novel sensing technology, in the form of the Microsoft SenseCam wearable camera, to help more accurately report dietary intake within various sporting populations. **Methods:** Participants were recruited to take part in this study which consisted of 3 groups: Group 1: trainee jockeys (n=17) Group 2: elite Gaelic footballers (n=15) and Group: 3 healthy physically active university students (n=15). Participants wore a SenseCam for 16 hours (from morning until night) while simultaneously keeping a 1- day food diary. Comparisons were made between the energy reported in the food diary alone and the food diary in conjunction with information gathered from the SenseCam. **Results:** Mean total calorie intake using the food diary alone compared to the combination of the food diary and SenseCam were 2349±827.9 vs 2631±893.4 kcal, 2600±521.9 vs 3191±770.2 kcal and 2237±318.5 vs 2487±404.6 kcal for the trainee jockeys, Gaelic footballers and University students respectively. This represented a difference of 10.7% ($p\leq0.001$); 17.7% ($p\leq0.001$); and 10.1% ($p\leq0.01$) among measurements methods for trainee jockeys, Gaelic footballers, and university students, respectively. No significant differences were seen between the mean energy intakes for the three groups. **Conclusions:** Results from this first study suggest that a more accurate estimate of total energy intake is provided when combining the use of conventional food diary and the SenseCam. Additional information on portion size, forgotten foods, leftovers, and brand names can be obtained by using this novel sensing technology in conjunction with the diary, with an improved and more accurate dietary assessment being a potential outcome. Being that this study is effectively a “feasibility study” and evaluated only one single day’s intake, future studies should increase the data collection period to a minimum of three days.

4.2 Introduction

Horse racing is a weight category sport and as such jockeys are subject to many of the challenges typically associated with participation in sports of this nature. One of the key challenges facing jockeys is the pressure of making weight and staying at weight throughout the protracted racing seasons. In order to provide individually tailored nutritional advice it is first necessary to accurately assess the jockeys' dietary intake. The most common dietary assessment method employed with athletes is by completion of a standard food diary, with 3-7 days being the recommended duration Black, (2001), which has shown to be the easiest and least invasive method of dietary assessment (Magkos and Yannakoulia, 2003). Despite their widespread use, evidence suggests that self-reported energy intake using food diaries frequently and substantially underestimates true energy intake (Black, 2001, Magkos and Yannakoulia, 2003). Magkos and Yannakoulia (2003) suggest that there are subtle methodological differences in the dietary assessment of athletes and non-athletes and that special attention should be paid to standard portion sizes, frequency of snacking, fluid intake, supplement use, weight control practices, and seasonality of sport activities and food consumption, when assessing athletes' diets.

A recent study Dolan et al., (2011b) examining dietary intake in eighteen professional jockeys reported a low mean energy intake in both Flat and National Hunt jockeys. The estimated resting metabolic rate for the jockeys was 1479±124 kcal.day^{-1} (Flat 1393±47 kcal.d^{-1}; National Hunt: 1614 ± 71 kcal.d^{-1}). This meant that mean energy intake was theoretically sufficient to support a physical activity level (PAL) of 1.22±0.36, approximately 22% above resting metabolic rate. An energy intake 1.2 times above resting metabolic rate, is equivalent to maintenance of the metabolic needs of men during bed rest Manore & Thompson, (2006) not a professional jockey with an active lifestyle. This raises the question are the jockeys operating in a chronic energy deficient state or is there a level of under-reporting in this group. The primary focus of the present study is to evaluate and compare the dietary intake in jockeys using both a standard food diary and the SenseCam to investigate if under reporting does exist and if so to what extent.

Aim

To examine the use and impact of a novel sensing technology in the form of the Microsoft SenseCam wearable camera to help more accurately report dietary intake within different physically active and athletic populations.

Objectives

- To collect a one day food diary and image data from SenseCam from each participant.
- To analyse reported calorie intake using WinDiets food data base to obtain a total nutrient summary of the food diary.
- To compare the total nutrient summary from the food diary alone and the combination of the food diary and SenseCam to evaluate potential discrepancies in the former.
- To compare the result from the jockeys with those for elite Gaelic footballers and healthy university students

Hypothesis

1. There will be a significant difference in reported calorie intake associated with traditional one day food diaries compared to the calorie intake of a one day food diary in conjunction with SenseCam image data.
2. There will be a significant difference in mean energy intakes between the three populations.

4.3 Methodology

4.3.1 Research Design Overview

A quantitative research design was employed in this study. Forty seven participants comprising of jockeys (n=17); Gaelic Athletic Association (GAA) footballers (n=15); physically active University Students (n=15) kept a standard one day Food Diary and also wore a SenseCam for the same day from 6 am till 10 pm. Dietary intake was assessed through the use of the traditional Food Diary which was compared to the novel method of assessing energy intake using the Diary along with the SenseCam (Figure 4.1). A pilot study using 6 trainee jockeys (4 male and 2 female) was initially completed. Ethical approval for the study was granted by the DCU research ethics committee.

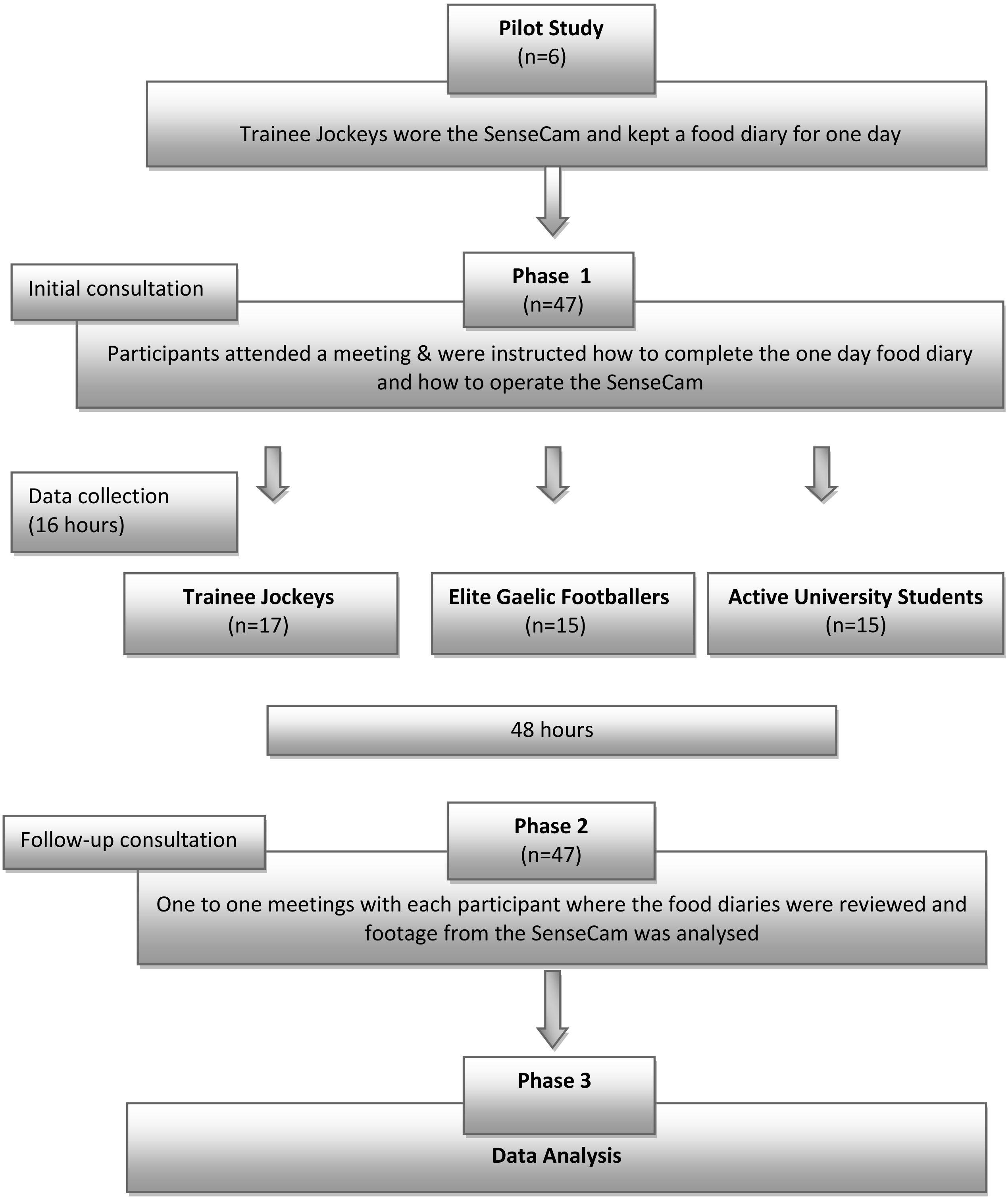


Figure 4.1 Schematic Representation of the Study Design Overview

4.3.2 Participants

A total of 47 subjects volunteered to participate in the study. Subjects consisted of 3 groups. Group1: 17 trainee jockeys (13 male and 4 female); Group 2: 15 male collegiate Inter county Gaelic footballers and Group 3: 15 physically active university students (10 male and 5 female).

The trainee jockeys were recruited from Ireland's Racing Academy and Centre of Education (RACE) and consequently they resided at the training academy form Monday till Friday. All of their meals were provided by the in-house canteen. The Gaelic footballers were all inter-county players, playing at the highest level, and also members of the Dublin City University (DCU) Sports Academy and trained at least four times per week, and played a match at least once a week. The University students were recruited from the wider DCU population and were physically active university students, undertaking structured physical activity a minimum of twice a week. The Gaelic football and university student groups were free to eat in any environment.

All participants received and read a plain language statement (see appendix 1) which explained the purpose of the study and what was required in order to participate. Subjects were also provided with further information and provided with the opportunity to ask questions about the study during an initial consultation meeting with the principal investigator. During this meeting each subject was also shown how to complete the food diary and operate the SenseCam. All participants signed a consent form prior to beginning the study (see appendix 2). Subjects recruited who were under the age of consent were required to have an informed consent form signed by their parent or legal guardian (see appendix 3).

4.3.3 Pilot study

Prior to the implementation of the study, a pilot study was completed using 6 trainee jockeys 4 male and 2 female aged between 16-18 years recruited from RACE in order to validate all the testing procedures. The pilot study involved testing the use of the food diary along with the SenseCam to identify and highlight any difficulties the trainees may have using the diary and the SenseCam. Signed informed consent forms were obtained from the trainee jockeys themselves or their parents, if under the age of consent.

A meeting was arranged with each participant prior to implementing the pilot study and given verbal and written instructions on how to complete the food diary correctly and instructions on the operation of the SenseCam. The subjects were asked to record all food and fluid intake in the food diary over a 16 hour period while simultaneously wearing the SenseCam. The time period of data collection was from when they got up in the morning until when they went to bed that night.

Having completed the data collection, a review meeting was held with each subject. The footage from the SenseCam was uploaded onto a lap top and then compared to what was written in the diary. Any difficulties identified in using the food diary and the SenseCam were discussed and noted. A number of errors occurred with regards to the operation of the SenseCam and so the written step by step instructions were amended accordingly in order to minimise operational error. This minimised the risk of wiping off the information. Following discussion it was evident that all participants in the pilot study fully understood the instructions on how to complete the food diary so no further edits were required.

4.3.4 Meeting with Subjects

4.3.4.1 Initial consultation

Prior to implementing the study a meeting was arranged with each individual subject where the study was explained in detail. Subjects were then briefed in detail on how to complete the food diary accurately and how to operate the SenseCam and were provided with written instructions (see appendix 4). Subjects were also given the opportunity to ask any questions.

4.3.4.2 Research Tools

The equipment used in this study was:

1. SenseCam (Microsoft, Vicon Revue, 3 MP) and

2. Food Diaries Windiets dietary analysis package (http://www.rgu.ac.uk/**windiets**)

1. SenseCam

SenseCam (figure 4.2) is a small wearable passive capture camera, worn around the neck and developed by Microsoft Research in the UK (Byrne et al., 2008). It is fitted with a wide angled (fish eye lens) that maximises its field - of – view Hodges et al., (2006b) thus capturing anything within the view of the wearer (Byrne et al., 2008) (figure 4.3). In addition to being a camera, a number of different electronic sensors are built into the SenseCam: a 3 megapixel sensor, temperature sensor, and a light, colour and intensity sensor. It also contains a multi-axis accelerometer and a compass. The Sensors are monitored by the Camera's microprocessor, and certain changes in sensor readings can be used to automatically trigger a photograph to be taken. For example a significant change in light level, or the detection of body heat in front of the camera can be used as triggers (Hodges et al., 2006b). Additionally due to an internal timer, the SenseCam will automatically take a photo approximately every 30 seconds, capturing up to 2500 - 3000 images per day (Lee et al., 2008, Kelly et al., 2013b). This provides the user with an extensive collection of images or a visual diary of their day. The SenseCam, was originally designed for use within the domain of Human Digital Memory to create a personal life log or visual recording of the wearer's life, which can be helpful as an aid to human memory (Byrne et al., 2008). However it is now clear that SenseCam can be applied to a vast array of situations and environments, in this particular case dietary assessment. For the purposes of the study the subjects were asked to wear the SenseCam around their neck (see Figure 4.3), secured to their chest with a Velcro strap, from days start till days end (excluding bathing) and were provided with written and verbal instructions. The subjects wore the SenseCam while riding out usually under their jackets if raining. It was not worn during races.

Figure 4.2 The Vicon revue SenseCam

Figure 4.3 A trainee Jockey Wearing the SenseCam

Figure 4.4 An image taken with SenseCam

2. Food Diary

A one day food diary was adapted from a seven day food diary previously used in a study with Professional Irish Jockeys (Dolan et al., 2011). The diary detailed full instructions on completing the diary as accurately as possible (see appendix 5). This required participants recording all food and fluid intake, the portion sizes and amounts of each consumed over the course of a day (16 hours). The amounts consumed were measured in household measures (such as cups, tablespoons). Participants were required to document the time at which foods was consumed in addition to the food, brand name, and quantity (e.g. Yoplait full fat strawberry yoghurt 125g). Helpful hints were given in the diary along with examples of ready prepared meals and take away meals. For example if cheese was consumed subjects were prompted to include what type of cheese whether it was soft or hard and regular verses low fat. If chicken was consumed, subjects were asked to specify if it was leg, wing and/or breast or white meat only, and whether the skin was eaten or not.

Each subject was shown how to accurately report their food size portions, preparations methods, food types and brand names if possible in the food diary. A book entitled 'Carbs, Cals, Fat and Protein' Cheyette and Balolia, (2010) was used as a reference guide for portion sizes when advising the subjects on how to accurately document portion size and when viewing images from the SenseCam. The book is a visual guide to over 500 food and drink items, detailing their respective weights and a breakdown of the calories, fat, protein and carbohydrate content.

4.3.4.3 Follow–up consultation

A follow up meeting occurred with each subject the day after testing with a professional dietitian with extensive experience of working with athletes and the data collected were reviewed. The food diaries were scrutinized in the presence of each participant so that any ambiguities regarding the quantity, incomplete entries, or vague descriptions could be clarified at that time. Details from the food diary were cross-referenced with a food reference manual (Cheyette and Balolia, 2010).

The footage from the SenseCam was then reviewed in the presence of each individual participant and any extra foods consumed or differences in portion size were documented. At this point it was possible to note specific food brands consumed and also if there were any leftovers after the meal had been eaten. The two sets of recorded information, the diary alone and the diary plus SenseCam data, were entered into a dietary analysis package (Windiets, http://www.rgu.ac.uk/**windiets**) that allowed determination of total calorie intake.

4.3.5 Dietary Analysis

Windiets food database for Windows (http://www.rgu.ac.uk/**windiets**) was used to acquire total nutrient summaries (figure 4.5) for each subject's food diary and subsequently their food diary with SenseCam. Once the data were analysed for the food diary alone the dietitian would then add in any changes for example; a different portion size or additional foods seen in the images from the SenseCam but not recorded in the diary, to the analysis of the diary. The two results were then compared and a record of the difference between energy intakes was kept. Windiets consists of 13378 UK food labels, 336 supplements and 1603 restaurant items plus 44,008 international foods to help with ethnic diets. The user can select foods from a list and enter their weights; an option to add local foods is also available if not already listed.

NUTRIENT		AMT	
Energ	kJ	8239	
kcal	kc	1956	
Fat	g	75.2	33.6 % energy
SFA	g	31.9	14.3 % energy
PUFA	g	8.3	3.5 % energy
Monos	g	28	12.5 % energy
Prot	g	65.5	13.6 % energy
CHO	g	272.3	52.8 % energy
Sugrs	g	129.4	25 % energy
Strch	g	142.6	27.7 % energy
NMES	g	84.1	16.3 % energy
NSP	g	7.9	
Alcoh	g	0	0 % energy
Water	g	1492.1	
VitA	ug	544	
Thiam	mg	1.31	
Ribof	mg	2.45	
Niac	mg	29.1	
VitB6	mg	1.97	
B12	ug	6.58	
Fol	ug	226	
Pant	mg	4.8	
Biot	ug	34.2	
VitC	mg	18.3	
VitD	ug	1.77	
VitE	mg	7.84	
Ca	mg	855	21.38 mmol
Mg	mg	204	8.4 mmol
Na	mg	2430	105.65 mmol 6.17 g as salt

Figure 4.5 Typical Nutrient Totals Output for WinDiets (WinDiets, RGU, Aberdeen)

4.3.6 Data Analysis

Data were analysed using SPSS, version 16.0. A paired *t* test ($p \leq 0.05$) was used to explore whether there was a difference between the mean calorie intakes from the diary alone versus from the diary plus SenseCam combination. A one-way ANOVA test was performed on the three different groups to see if there was a significant difference in the total energy intakes between the groups and if there was a significant difference between the level of under-reporting between the three groups.

4.4 Results

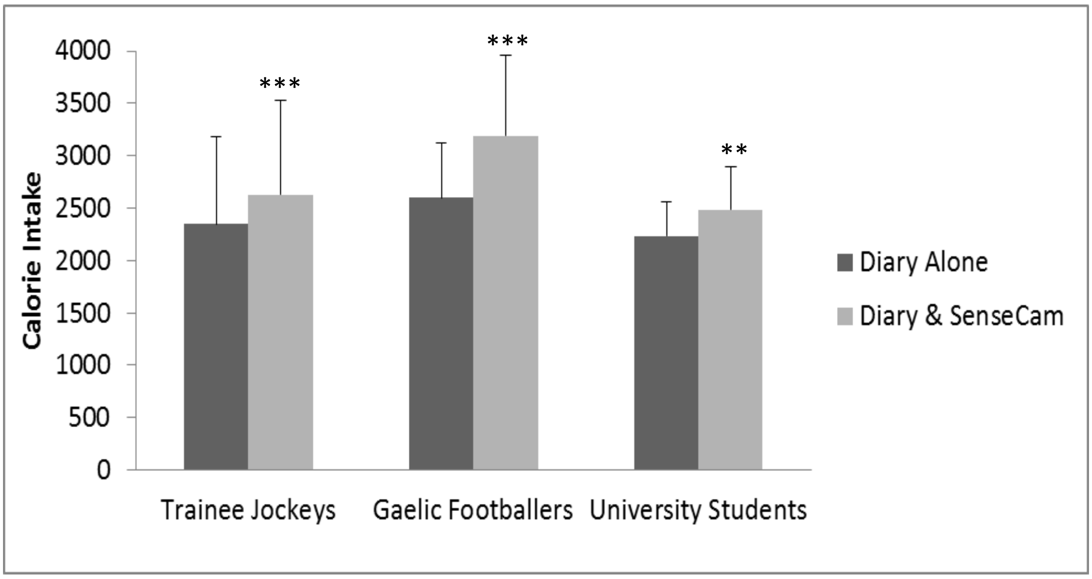
4.4.1 Descriptive Data

Subjects consisted of 17 trainee jockeys (male n = 13, female n=4, age 18 ±2 years); 15 elite collegiate Gaelic footballers (male n = 15, age 22±1 years) and 15 physically active university students (male n= 10, female n = 5, age 23±1 years).

Six (35%) of the trainee jockey group; 5 (33%) of the Gaelic footballers group and 2 (13%) of the University student group were removed from the final data analysis because of incomplete data being recorded caused by a combination of camera or user error, leaving 11, 10 and 13 participants to be analysed, respectively. Only one participant from all groups (female jockey) had a food diary that matched the information obtained from the SenseCam.

4.4.2 Dietary analysis

Mean total calorie intake amounts using diary alone when compared with the combination of the diary plus SenseCam were as follows: 2349±827.9 vs 2631±893.4 kcal for the trainee jockeys; 2600±521.9 vs 3190±770.2 kcal for the Gaelic footballers; and 2237±318.5 vs 2487±404.6 kcal for the University students (see Figure 4.5). Differences among measurement methods of 10.7% ($p \leq 0.001$), 17.7% ($p \leq 0.001$), and 10.1% ($p \leq 0.01$) were reported for the trainee jockeys, Gaelic footballers and university students, respectively (table 1).



Data presented as mean ± SD *p≤0.05, **p≤0.01, ***p≤0.001

Figure 4.6 Comparison of Energy Intake Using Two Dietary Assessment Methods in Various Groups

There was no significant difference in the energy intakes using the food diary and the SenseCam between the three different groups studied. However further analysis revealed a significant difference ($p \leq 0.05$) in the level of under – reporting between the three groups when the data for the food diary alone and the food diary combined with the SenseCam were compared, with the GAA players showing the highest discrepancy (17.7%). On further analysis of the jockeys' one days' dietary analysis a mean carbohydrate intake of $393.5g^{-1}$ which amounts to $7.2g.kg^{-1}$ was shown, based on the mean body mass of 54.8 kg, 102.8g $protein^{-1}$ which was $1.9g.kg^{-1}$. Fat intake was calculated to be 28% of overall mean energy intake. The mean calcium intake was 1183±641 with a range of (672-2907 mg). Vitamin D levels were $1ug\pm0.81^{-1}$. The dietary fibre intake was low at a mean of $6.6\pm3.6g^{-1}$.

Table 4.1 Mean Difference in Energy Intake between Two Dietary Assessment Methods

	Mean Difference (kcals)	Mean Difference (%)
Trainee Jockeys	282 +- 164	10.7***
Gaelic Footballers	591 +- 304	17.7***
University Students	250 +- 216	10.1**

Data presented as mean +- SD; *p≤0.05, **p≤0.01, ***p≤0.001

4.5 Discussion

The purpose of this study was to examine the use and impact of a novel sensing technology in the form of the Microsoft SenseCam wearable camera to help more accurately report dietary intake within different physically active and athletic populations. Participants were asked to keep a traditional one day food diary while simultaneously wearing the SenseCam. The data were then analysed to see if the diary and SenseCam together provided a more accurate recall of intake than the diary alone. It was hypothesised that there would be a significant difference in reported calorie intake associated with traditional one day food diaries compared to the calorie intake of a one day food diary in conjunction with SenseCam image data. The results of this initial study suggest that SenseCam may provide useful benefits in terms of augmenting established techniques for recording energy intake. It was also hypothesised that there would be a significant difference in mean energy intakes between the three populations. Surprisingly results indicated that this was not the case as there was no significant difference between the energy intakes between the three populations. It should be noted however that this was a feasibility study and data were collected over just one day. For future studies the period of data collection should be extended to a minimum of three days.

Previous studies evaluating diet and lifestyle characteristics of jockeys have found that typical dietary intake is low in energy and inadequate in key micronutrients. However those studies focused on professional jockeys Labadarios et al., (1993); Leydon & Wall (2002) habitually making weight on a regular basis and required to follow calorie controlled diets. In contrast the current study focused on trainee jockeys, most of who were between the ages of 16 – 18 years and not actively making weight, on a regular occurrence, at this early stage of their career. In fact as part of the nutritional educational programme run through RACE, trainee jockeys would be encouraged to meet the energy requirements of an active 16 – 18 year old which would be between 2400 – 2800 kcals^{-1} for males and 2000 kcals^{-1} for females (FSAI, 2011). However it is still surprising that there was no significant difference between the mean energy intake between the three groups. It would be expected that the Elite Gaelic Footballers would be consuming a higher energy intake than trainee jockeys. The reason for this may be that while the trainee jockeys are living in RACE they have meals provided for them and there would be little pressure at this point of their careers to make weight. The mean energy intake for the trainee jockeys for the 1 day analysed, using the SenseCam and the food diary was 2631± 893, with a range of between 1409 – 4011 kcals $^{-1}$ indicating that some of the trainees were consuming well above the recommended daily requirements for energy intake while some were not meeting their full requirements. This concurs with a study of New Zealand jockeys which reported wide energy fluctuations which were attributed to a difficulty in making appropriate food choices (Leydon and Wall, 2002). This study was a feasibility study and data was collected over just one day. By virtue of using just a one day dietary recall it provided merely a snap shot of the participants habitual intake. Future studies would have to look at data collection over a longer period a minimum of three days would be recommended. When the mean energy intakes from the three different groups were compared there was no statistical difference between them ($p \geq 0.05$). On closer examination of the food choices made by this group it is evident that there is a considerable amount of snacking on energy dense confectionary. Portion controlled meals are provided for the trainees at RACE, however there is access to the local sweet shop and a large amount of confectionary is consumed. A heavy reliance on convenience foods appears to continue into the jockeys later life (Wilson, 2012). The result of this study highlights the need for continued nutrition education around healthy food choices and portion control early on in the jockeys' training/career.

Taking into account the limitations associated with a one day food record, a closer evaluation was undertaken into at the macro and micronutrient composition of the trainee jockey group. When the nutritional data of the male participants alone was assessed, the analysis shows the diets were typically low in fibre with mean intake at only 6.6g^{-1} falling far below the recommended 27.7g per day. While carbohydrate comprised 60% of mean energy intake, almost 50% of total intake was derived from sugar. Mean calcium intake was 1229 mg^{-1} ±701 which did not meet the daily recommendation of 1417mg^{-1} for active males (14-18 years), four of the participants managed just over half of the daily requirement. Vitamin D intakes were low at a mean of 1.05ug $^{-1}$. A mean of 1.9g protein.kg^{-1} was reported and 28% of energy came from fat (FSAI, 2011).

There was a significant difference ($p \leq 0.05$) between the levels of under – reporting between the three different groups. The GAA players were shown to have the highest level of under-reporting with a mean value of 591±304 kcals. One player under-reported by 1139 kcals. Interestingly the highest calorie differences (1139 and 1074 kcals) were seen with those who had the highest original food diary energy intakes (3320 and 3275 kcals) respectively). This is in agreement with Subar et al., (2003) who claim that under-reporting tends to increase with increased intake, because the more respondents require or consume, the more difficult it is to report consumption accurately, perhaps because remembering more foods or larger portion sizes is challenging or because of societal pressure to consume less.

Of the limited studies investigating dietary intake patterns in jockeys, most have used a food record and/or a 24 hour recall method of assessment (Labadarios et al., 1993, Leydon and Wall, 2002, Dolan et al., 2011b). It is well documented that these methods of dietary assessment are not without their limitations, with high levels of under-reporting due to both under-eating and under-recording. The main areas of discrepancy between the food diary and the Sensecam were snacks, condiments and portion size. Jockeys were seen eating sweets while in the car. A number of diaries omitted condiments such as tomato sauce, mayonnaise and side orders such as coleslaw. Estimation of portion size was inaccurate at times e.g breakfast cereal, wedges at dinner time, generally underestimating the portion consumed. Studies have also shown that the more that is consumed the more likely it is to be incorrectly recorded Magkos & Yannakoulia, (2003); Rutishauser, (2005); Black (2001)(Magkos and Yannakoulia, 2003, Rutishauser, 2005, Black, 2001) therefore it was important to further investigate a method of dietary assessment which may increase the accuracy and confirm the true level of under-reporting, if it does exist, in both this group and other populations.

The results of this initial study suggest that SenseCam may provide useful benefits in terms of augmenting established techniques for recording energy intake. The images obtained from SenseCam provide additional information regarding dietary intake patterns and highlight significant under-reporting of calorie intake, ranging from 10% - 18% in the populations studied. This concurs with the results of a study by Mertz et al., (1991) who examined the dietary intake of 266 free living volunteers aged between 21 – 64 years of age. Evaluation of the subjects showed a mean difference between recorded and determined intake of 565 kcal in men and 428 kcal in women. This represented an underreporting of ~ 18% in both groups. A thorough review of the current scientific literature suggests that no previous research has been published examining the potential use of the SenseCam for dietary assessment. The current study thus stands as a “feasibility study”, indicating the potential value of the SenseCam in dietary analysis. The automatic nature of the SenseCam offers many advantages over studies using a user activated camera to log dietary intake. Requesting that individuals manually photograph before-after images of meals is dependent on subject compliance, is potentially intrusive and requires the individual to remember not only the camera but also to take photographs at appropriate times. Previous studies Higgins et al., (2009); Six et al., (2010); Zepeda & Deal (2008) have reported no general advantage in terms of accuracy in using a conventional camera to capture dietary intake over food diaries because of participant burden and incomplete photographic records, due to participants forgetting to take the photograph until after they had eaten or forgetting to bring the camera altogether. A study by Higgins et al., (2009) did suggest, however, that the camera was less burdensome than the food diary for subjects of this age group and their parents preferred it as a method of recording dietary intake.

The process of recording food consumption has been shown previously to influence habitual dietary practices to the extent that alternate choices may be made, as participants are aware that their diary will be analysed (Eertmans et al., 2001). Mac Diarmuid and Blundell (1998) found that food items with a negative health image (e.g. cakes, sweets, confectionary) are more likely to be under-reported, whereas those with positive health image are more likely to be over reported (e.g. fruits and vegetables). During the current study, each subject wore the SenseCam and simultaneously completed a food diary for a 1 day period (~16 hours). When conducting dietary analysis over more extended periods, the SenseCam may become more valuable because of decreased enthusiasm for diary logging by participants over time. This was demonstrated by a study by Rebro et al., (1998) which found that after day 4 of keeping a 7 day food diary nutrient intake decreased. The authors attributed this to a possible decrease in the participant's ability to complete the food record rather than an actual decrease in food intake. In any future studies looking at dietary intake in jockeys the SenseCam would provide a valuable tool to validate the accuracy of the diary and because it works automatically, it is not subject to reporting biases. Jockeys typically lead hectic lifestyles, eating mainly "on the go" and are unlikely to carry a pen and paper with them while riding out or racing. This makes accurately recording habitual intake using a standard food diary problematic and may result in error from both the recording aspect and the accuracy from the coder's perspective. If the participant has a heavy reliance of convenience foods, such as 'take-aways', it is unlikely that an accurate assessment of dietary intake will be achieved, simply due to the variety of foods available when eating out. However with the SenseCam, a 'fly on the wall' view of critical events during the subject's day provides vital information on portion size and information on brands. There was no significant difference shown between energy intakes between the three different groups which is surprising as one would expect the intakes of GAA players to be considerably more than trainee Jockeys who are entering a career in which making weight is a crucial component to their sport. This highlights the importance of dietary education in this group. At an early age they may find it easy to keep their body mass low as they have higher energy requirements, however as they progress through their careers it may become harder to make weight with excessive energy and fat intakes and lower energy requirements. The recommended energy requirements for active males aged between 14-18 years is 2800 kcals.d^{-1} and for active females aged 14 – 18 years is 2000 kcals.d^{-1}, for the average adult male aged 19-50 years 2400-2800 kclas.d^{-1}, and for average adult female aged 19 – 50 years is 2000-2200 kcals.d^{-1} is recommended (FSAI, 2011). These recommendations are however for the general population and not for those participating in a weight category sport. Here in lies the dilemma while the trainees are encouraged to meet their recommended energy and nutrient requirements while training they also need to be able to prepare to enter the world of a weight category sport demanding high energy outputs with restricted energy input. It is imperative that they are given education at an early stage whereby they are taught how to maximise their intake of foods which are beneficial to them providing them with the essential nutrients they require e.g. calcium, Iron and other micronutrients and also how to identify foods which are less nutritionally balanced e.g. confectionary and the effects of over consuming these products. Individual meals plans for each jockey are required to steer them in the correct path for their future careers.

Many factors may explain the differences in calorie intake measured by the diary verses SenseCam in the current study. The automated nature of images captured on the SenseCam (up to 3000 photos per day) forms a comprehensive visual record of eating habits. This facilitates an image-by-image discussion with a dietitian, prompting questioning around what occurred during the day along with places visited (e.g. stopping at a garage where snacks were bought). Such questioning helps to jog an individual's memory and report more accurately what has been consumed. Leftover foods are often unaccounted for in food diaries whereas with the SenseCam it was possible for the Dietitian to observe any foods left on the plate, once the person had finished eating. Different food brand types can be identified, allowing a more precise assessment of energy intake in addition to a more accurate idea of portion size. With exact information of brands consumed it is possible for the dietitian to enter exact data into the analysis package making the assessment more accurate (Braakhuis et al., 2003). Despite precise written and verbal instruction on how to accurately complete a food diary, there was, as found with other populations Schwartz & Byrd-Bredbenner, (2006) clear lack of ability to determine portion size in the current study sample. Additionally, previous research has found that young adults experience portion distortion with some foods (Schwartz and Byrd Bredbenner, 2006). The current studies results highlight the continued need for more education around portion size. Small discrepancies in isolation may appear unimportant, but when accumulated over the course of a day may account for the noticeable under-reporting that occurs in a large proportion of diaries.

For a jockey, making weight is a crucial part of their sport, therefore being able to accurately assess the jockey's intake is vital in order to devise appropriate dietary advice to improve both weight making strategies and help improve performance. A jockey has a very small window of opportunity in which to consume adequate nutrition in a restricted amount of calories. Unfortunately, current evidence this population rely heavily on convenience foods which are high in sugar, fat and salt and low in fibre and vitamins and minerals (Dolan et al., 2011b). This issue needs to be addressed through appropriate nutrition education interventions as the jockey progresses along the pathway of his/her career and backed up with appropriate provision of food at their workplace, for example the Race track.

4.6 Limitations

Despite the potential benefits of the SenseCam, there were limitations associated with its use because of both user and camera error. Data captured with SenseCam were incomplete for a number of participants. As a consequence, the results from 13 subjects (28%) were removed from the final data analysis. Despite the provision of simple instructions on how to operate and wear the camera, subjects repeatedly made errors, such as not wearing the camera properly and pressing the wrong buttons to switch it on and off. There were also some initial software problems that needed to be overcome.

Some photos were of low quality in poorly lit or dark conditions as no flash or infrared photo capture- capabilities exist for the SenseCam. Because it was a feasibility study only a 1- day period was investigated. Ideally 3-7 days should be monitored in order to accurately assess nutritional intake (Basiotis et al., 1987, Mertz et al., 1991). Black (2001) noted that, an increase in the number of observations (days), would result in a decrease in the effects of random errors. There were limitations regarding the life of the SenseCam battery. On average it functions for 18 hours after which time the participant is required to re-charge the SenseCam. If the SenseCam is left uncharged for more than a few days it can go into 'sleep mode' and may need to be rebooted resulting in all recorded data being lost. With the amount of user error which occurred in this study it made it impractical to use for more than the 16 hour period. For future studies a 3 day recording period would be more desirable to further increase accuracy.

The SenseCam does not enable the automated estimation of the volume of the foods captured in the images (Six et al., 2010). Furthermore, it does not provide information on the calories consumed. Sensing devises are currently being developed which will be able estimate volume and calorie content and the use of these in the future should be considered (Zhu et al., 2010).

Manual coding of the images along with coding of the diary is time- consuming. Therefore a device which could automatically download the information to the Dietitian's computer would be more beneficial.

Confidentiality can also be an issue when the SenseCam is being used, there is a secrecy button which can be pressed which freezes the camera for one minute, which allows the subject more control over what is being recorded. Research using automated, wearable cameras, by its nature can be very intrusive, and particularly third parties may feel uncomfortable. It is therefore important that the researcher fully informs the participant on the possible scenarios that may occur using the cameras and receives informed consent from the participant. Respect for anonymity through appropriate approaches to informed consent and adequate privacy and confidentiality controls, allow for ethical research to be carried out (Kelly et al., 2013a).

4.7 Conclusion

The aim of this study was to examine the efficacy of using the SenseCam along with a standard food diary, to see would it yield a more accurate assessment of dietary intake. A difference was reported in the mean total calorie intake of the diary alone compared to the SenseCam and the diary, suggesting significant under-reporting. Results from this study suggest that a more accurate estimate of total energy intake is provided using the diary in conjunction with the SenseCam. Additional information on portion size, forgotten foods, left overs and brand names could be obtained by using the wearable cameras in conjunction with the diary, with the potential to improve dietary assessment in a number of different populations. Overall the results of the current study indicate that the SenseCam may provide a valuable tool in the assessment of food intake through verifying and expanding on the data captured using a conventional diary, thereby augmenting the accuracy of the dietary information provided.

For a jockey, making weight is a crucial part of their sport, therefore being able to accurately assess the jockey's intake is vital in order to devise appropriate dietary advice to improve both weight making strategies and help improve performance. Once issues of confidentiality are carefully explained to the participant and consent is given, the SenseCam can provide a valuable research tool and provide substantial benefits in increasing the accuracy of dietary assessment in both the general and sporting populations.

Chapter Five: Summary, Conclusions and Recommendations for Further Research

5.1 Summary

This thesis was divided into to two distinct but inter-related studies. Study 1: examined the habitual dietary intake of jockeys, over a seven day period. To date, despite horse racing being one of the most demanding weight category sports, only a limited number of studies have investigated at the dietary practices of jockeys (Labadarios et al., 1993, Leydon and Wall, 2002, Moore et al., 2002). This study was the first of its kind in Professional Jockeys in Ireland which is one of the world's leading horse racing nations. The intention was to further investigate the accuracy of the findings of study 1 and to further evaluate whether the chronic energy deficiency reported was an accurate reflection of poor dietary habits in this population or was in part due to a certain level of under-reporting/under- eating associated with the method of dietary assessment used. Novel sensing technologies, in the form of the SenseCam < were incorporated into study 2: to determine if there was a new dietary assessment tool which could be used to increase the accuracy of dietary assessment. The SenseCam, initially developed as a memory aid for patients with Alzheimer's disease, was trialled in tandem with a standard one day food diary and results compared to see if accuracy was improved. The study was expanded to encompass two other sporting populations. It was intended that the findings from this research would provide a scientific basis for the development of specific guidelines to assist jockeys making weight for competition as well as improving their overall lifestyle and subsequently health, well- being and performance throughout their racing careers.

Study 1 examined the habitual intake of 18 professional Irish jockeys. This study was part of a larger study investigating lifestyle and weight control practices of 27 professional Irish Jockeys. Participants were required to keep a food record over a seven day period. The results were analysed using a dietary analysis package and results compared with the recommended daily intake for the Irish population. The results were also compared with guidelines for athletes by the American Dietetic association and guidelines for weight category sports (American Dietetic Association, 2009, Sundgot-Borgen and Garthe, 2011). Findings from the study implied that, jockeys were operating in an energy restricted state. Their diets were low in both macro and micro-nutrients. The observed low energy intake was also associated with suboptimal intake of calcium and Iron and other micronutrients, as evidenced in the study's findings. Of particular interest was the substantial proportion of the sample failed to meet the recommended daily allowance for most nutrients recommended for athletic populations. Although this may not be of concern in the short-term, the need to habitually make weight on numerous occasions throughout the course of an extended racing season and the ongoing need to maintain body mass within strict limits may lead to compromised vitamin and mineral status in this population, which may have potential long-term health implications Results from this study concur with similar research in jockeys in other horse racing nations. It was estimated that energy availability was well below the recommended 30-45 kcal.kg FFM^{-1} at 8 kcal.kg LBM $^{-1}$ ± 12 kcals. Using the Goldberg cut off, it was estimated that the energy intake was sufficient to meet the metabolic needs of a man at rest not a physically active jockey.

It is well recognised that the ‘food record’ method of dietary assessment has its limitations with associated levels of under reporting of anywhere between 10-40%. Study 2 therefore was undertaken to investigate, the level, if any, of under-reporting/under eating that existed in this population. The novel sensing technology adopted was the SenseCam; a small wearable camera which reacts to light and movement and automatically takes up to 3000 images per day which was employed along with a standard one day food diary. The study comprised of 17 trainee jockeys and was later expanded looking at two other sporting populations, elite Gaelic footballers and physically active university students who engaged regularly in sport. The images obtained from the SenseCam provided additional information regarding dietary intake patterns and highlighted significant under-reporting of calorie intake, ranging from 10 % - 18% in the populations studied.

To the authors knowledge no previous research has been published examining the potential use of the SenseCam for dietary assessment. This study stands as a “feasibility study”, indicating the potential benefit of the SenseCam in enhancing the resolution and accuracy of standard dietary analysis techniques using a food diary. Of particular note the current study reported that there was a mean of 10.7% difference in energy intake when the camera was used along with the diary, with the trainee jockeys. Only one out of the 17 trainee jockeys (6%) who participated in the study correctly completed the food diary. Due to the need to continuously make weight, jockeys have a small window of opportunity in which to achieve their nutritional requirements. The SenseCam provided an invaluable ‘fly on the wall’ look into the life of a jockey and highlighted the poor dietary choices made by jockeys. It proved to be an invaluable tool not only in enhancing established dietary assessment techniques but also it enabled the dietitian to educate the jockeys regarding behaviour change in order to make better dietary choices in the future.

This research has added to the existing body of research by providing a deeper insight into the dietary practices of jockeys in an attempt to improve health, well-being and overall performance of jockeys. The findings of this research indicate that conventional dietary assessment methods used in this weight category population may not provide a sufficient degree of accuracy or reliability and alternative methods may need to be incorporated to increase the precision and resolution of traditional dietary assessment methods. This study highlighted the poor dietary practices of both professional and in some cases the trainee jockeys. It further emphasised the need to provide an early education intervention during the initial stages of a jockeys career in order to increase the likelihood that good dietary practices are formed at an early age. The findings also further highlight the need to develop sport specific nutrition and training guidelines to encourage jockeys to use healthier forms of weight maintenance to protect them throughout their sporting careers.

5.2 Study Implications and Conclusion

Making weight and remaining at a stipulated weight throughout the prolonged racing season represents a major challenge to jockeys who compete in this extreme weight category sport. This research aimed to investigate the dietary habits of jockeys in Ireland and examine whether or not they were meeting their recommended nutritional goals. The results from the first study highlighted that due to the nature of the sport the erratic lifestyles led by jockeys, it was difficult to accurately assess intake through conventional methods of dietary assessment and so a novel method was employed. The overall aim of the two studies was to get an accurate picture of dietary practices employed by jockeys and to develop nutrition guidelines to help them make weight an easier and healthier way than was currently being used. Jockeys follow a life of chronic energy restriction due to the unrealistic weights they are expected to achieve. The population is increasing in size however the weight structures, based mainly on tradition, have not increased accordingly. This puts ever increasing pressure on jockeys to find ways to unnaturally attain these weights. This is especially the case with young apprentice jockeys who are still maturing, the reliance on unhealthy weight making strategies needs to be limited amongst jockeys. As a consequence of this current research, the minimum weights of Flat jockeys have been increased on 2 occasions. Additionally a new minimum weights structure for apprentice jockeys, designed to establish individualised minimum riding weights, has now been brought into Ireland to encourage the adoption of safer weight making practices through dietary and exercise education programmes. All apprentice jockeys have now been given individual dietary advice and assigned a minimum riding weight based on their anthropometrical characteristics and previous riding weights. Once an individual minimum weight has been established, a jockey can no longer accept rides below their stipulated minimum riding weight. Further research has been undertaken within our research group, to evaluate the specific physiological demands of jockey during racing and other activities associated with a jockeys lifestyle, in order to allow the development of a scientific base of necessary information so that sport specific nutritional and training guidelines could be provided to the individual jockeys to encourage the adoption of healthier weight making practices. International collaboration and consensus is necessary on the minimum weight structures to ensure that the international competitive nature of the horse racing industry can accommodate these changes in the interest of the health, safety and well-being of jockeys as a whole. A 'Jockey Pathway' has been developed which looks at the core capacities of jockeys at each stage of their career and the alignment of appropriate support structures at each stage of development to address the necessary requirements.

While great strides have been made in assessing the jockeys' needs, support structures on the ground need to be further improved. One of the main reasons cited by jockeys for poor compliance to dietary guidelines is the lack of provision of appropriate foods available at the race tracks. In other countries this service is readily available and while it does not solve all the problems it makes adherence to dietary recommendations easier to achieve. Jockeys eat 'on the run' most of the time and this leads to heavy reliance on convenience foods which are generally energy dense, high in fat and sugar and low in fibre and micronutrients. Continued dietary and training education along with the appropriate support systems made readily available to jockeys is needed to encourage the adoption of healthier weight making strategies. This will assist the jockeys in enhancing their health, well-being and overall performance throughout their sporting career and indeed the rest of their lives.

5.3 Recommendations for Further Research:

Results from this research suggest that professional jockeys' typical dietary intake is low in energy and inadequate in key micronutrients. The results of this study provide a greater depth of understanding of the degree of energy and micronutrient deficiency experienced by jockeys and shows that poor dietary intakes previously reported in jockeys in other countries remain prevalent in jockeys today. The second study confirmed that the traditional methods of dietary assessment are limited in their accuracy and that the introduction of a new sensing technology such as the SenseCam may help with future research into dietary habits of jockeys. As this was essentially a “feasibility” study and provided merely a snap shot of a jockeys’ habitual intake, future research should aim to increase the data collection period to a minimum of 3 days. To limit any changes to dietary practice due to wearing the SenseCam the participants may be told in future studies that the camera is being used to measure exercise levels rather than diet. The study also suggested that the SenseCam could be used as a useful behavioural change tool when educating jockeys regarding their diets. Due to lack of appropriate support structures most jockeys have no precise, safe weight making strategies. Clearly further research of the physiological and energy demands of racing is needed along with evaluation of metabolic and hormonal markers of energy balance so as to determine if a state of energy imbalance does exist. There are limitations related to accurately assessing micronutrient intakes over short periods of time therefore biochemical analysis of blood or tissue should be carried out to confirm if deficiency exists. For future studies an alternative statistical test ‘The Bland-Altman approach’ should be considered as this would compare the difference between two measures vs the mean of the two measures with the data plotted via a scatter lot. This would show the limits of the agreement and provide a more comprehensive comparison of the two methods. It would also show the effect of higher energy intake and more likely under-reporting.

While this research provided many novel findings, it also generated many unanswered questions of which warrant further investigation. Further research is required to determine if jockeys are in fact in a metabolic state of energy imbalance and whether this may have an impact on resting metabolic rate. Future research should investigate further the energy requirements of this population using Indirect Calorimetry or Doubly Labelled Water. Further research is also necessary to investigate the physiological demands of racing. Such information may aid the development of more appropriate sport-specific nutritional and training guidelines for this group of athletes.

Bibliography

ACSM, ASSOCIATION, A. D. & CANADA, D. O. 2000. Joint Position Statement: Nutrition and Athletic Performance. *Medicine in Science in Sports and Exercise*, 2130-2145.

AMERICAN DIETETIC ASSOCIATION 2009. Nutrition and athletic performance. Position of the American Dietetic Association, Dietitians of Canada and American College of Sports Medicine. *Journal of the American Dietetic Association.*

AMERICAN MEDICAL ASSOCIATION 1998. Hyperthermia and dehydration-related deaths associated with international rapid weight loss in three collegiate wrestlers - Noth Carolina, Wisconsin, and Michigan. *Journal of American Medical Association,* 279**,** 824-5.

ANONYMOUS 1993. Consensus Development Conference: Diagnosis, Prophylaxis and Treatment of Osteoporosis. *American Journal of Medicine,* 94**,** 646-650.

BASIOTIS, P., WELSH S O, CRONIN FJ, KELSAY JL & W, M. 1987. Number of days of food intake records required to estimate individual an dgroup nutrient intakes with defined confidence. *American institute of Nutrition* 117**,** 1638-41.

BEATON, G. 1994. Approaches to analysis of dietary data: relationship between planned analyses and choice of methodology. *The American Journal of Clinical Nutrition,* 59 (1)**,** 253(s)-261(s).

BLACK, A. 2000. The sensitivity and specificity of the Goldberg cut-off for energy intake: basal metabolic rate for identifying diet reports of poor validity. *European Journal of Clinical Nutrition,* 54**,** 395-404.

BLACK, A. E. 2001. Dietary Assessment for Sports Dietetics. *British Nutrition Foundation Nutrition Bulletin,* 26**,** 29-42.

BRAAKHUIS, A. J., MEREDITH K, COX G, HOPKINS G & M, B. L. 2003. Variability in estimation of Self-reported Dietary Intake Data From Elite Athletes Resulting from Coding by Different Sports Dietitians. *INternational Journal of Sport Nutrition and Exercise Metabolism,* 13**,** 152-165.

BROWN, B., CHETTY M, GRIMES A & E, H. 2006. Reflecting on health: a system for students to monitor diet and exercise. *CHI '06 Extended abstracts on Human Factors in computing systems.* New York.

BROWNELL, K., STEEN, S. & WILMORE, J. 1987. Weight regulation practices in atheletes : analysis of metabolic and health effects. *Medicine and Science in Sports and Exercise,* 19**,** 546-556.

BURGE, C., CAREY M & W, P. 1993. Rowing performance, fluid balance and metabolic function following dehydration and rehydration. *Medicine in Science in Sports and Exercise,* 25**,** 1358-1364.

BURKE, L. 2006. Nutrition for recovery after training and competition. *In:* BURKE, L. & V, D. (eds.) *Clinical Sports Nutrition.* 3rd ed. New York: McGraw-Hill.

BURKE, L., KIENS B & JL, I. 2004. Carbohydrates and fat for training and recovery. *Journal of Sports Sciences,* 22**,** 15-30.

BYRNE, D., DOHERTY, A., JONES, G., SMEATON, A. F., KUMPULAINEN, S. & JARVELIN, K. 2008. The SenseCam is a tool for task observation.Proceedings of the 22nd British HCI Group Annual Conference on people and Computers. Culture, creativitiy, Interaction. *British Computer Society.*

CAULFIELD, M. & KARAGEORGHIS, C. 2008. Psychological effects of rapid weight loss and attitudes towards eating among professional jockeys. *Journal of Sports Sciences,* 26**,** 877-83.

CHEYETTE, C. & BALOLIA, Y. 2010. *Carbs and Cals and Protein and Fats.,* Great Britain, Chello publishing Ltd.

COTUGNA, N., SNIDER S O & J, W. 2010. Nutrition assessment of horse-racing athletes. *Journal of Community Health*.

DEAKIN, V. 2010. Measuring nutritional status of athletes ; clinical and research perspectives. *In:* BURKE, L. & V, D. (eds.) *Clinical Sports Nutrition.* 4th ed. Australia: McGraw-Hill.

DEUTZ, R. C., BENARDOT D, MARTIN D E & MM, C. 2000. Relationship between energy deficits and body composition in elite female gymnasts and runners. . *Medicine in Science in Sports and Exercise,* 32**,** 659 - 668.

DOLAN, E. 2010. *The impact of acute an chronic weight restriction and weight regulation practices on physiological, osteogenic, metabolic and cognitive function in Elite Jockeys.* Doctor of Philosophy, Dublln City University.

DOLAN, E., CRABTREE, N., MCGOLDRICK, A., ASHLEY, D., MCCAFFREY, N. & WARRINGTON, G. 2011a. Weight regulation and bone mass: a comparison between professional jockeys, elite amateur boxers, and age, gender and BMI matched controls. *Journal of Bone Mineral Metabolism,* 30**,** 164-170.

DOLAN, E., MCGOLDRICK, A., DAVENPORT, C., KELLEHER, G., BYRNE, B., TORMEY, W., SMITH, D. & WARRINGTON, G. 2012b. An altered hormonal profile and elevated rate of bone loss are associated with low bone mass in Professional Horse - Racing Jockeys. *Journal of bone and mineral metabolism,* 30**,** 534-542.

DOLAN, E., O'CONNOR, H., MCGOLDRICK, A., O'LOUGHLIN, G., LYONS, D. & WARRINGTON, G. 2011b. Nutritional, lifestyle and weight control practices of professional jockeys. *Journal of Sports Sciences,* 29**,** 791-799.

DOLAN, E., O CONNOR, H., MCGOLDRICK, A., O'LOUGHLIN, G., LYONS, D. & WARRINGTON, G. 2011c. Nutritional, Lifestyle and Weight Control Practices of Professional Jockeys. *Journal of Sports Sciences,* 29**,** 791-799.

DOLAN, E., WARRINGTON, G., MCGOLDRICK, A., O'LOUGHLIN, G. & MOYNA, N. M. 2008. Analysis of energy balance of professional jockeys on a competitive race day. *Medicine and Science in Sports and Exercise,* 40**,** S14.

EERTMANS, A., BAYENS F & O, V. D. B. 2001. Food likes and their relative importance in human eating behaviour : review and preliminary suggestions for health promotion. *Health Education Res,* 16**,** 443-56.

FILAIRE, E., MASO F, DEGOUTTE F, JOUANEL P & G, L. 2001. Food restriction, performance, psychological state and lipid values in Judo Athletes. *International Journal of Sports Medicine,* 22**,** 454-459.

FINLEY, B. 2005. Jockeys' Tragic Death Shows that Weights Must Change. *ESPN Horse Racing*.

FOGELHOLM, M. 1994. Effects of bodyweight reduction on sports performance. *Sports Medicine,* 18**,** 249-67.

FOGELHOLM, M. G., KOSKINEN R, LAAKSO J, RANKINEN Y & I, R. 1993. Gradual and rapid weight loss, effects on nutrition and performance in male athletes. *Medicine in Science in Sports and Exercise,* 25**,** 371-377.

FSAI 2011. Scientific recommendations for Healthy Eating Guidelines. Dublin: Food Safety Authority of Ireland.

GARTHE, I., RAASTAD T, REFSNES P, KOIVISTO A & J, S.-B. 2009. Is it possible to maintain lean body mass and performance during energy - restriction in elite athletes ? *Medicine in Science in Sports and Exercise,* 41**,** 9.

GIBSON, R. 2005. Principles of Nutritional Assessment. 2nd ed. New York: Oxford University Press.

GITTELSOHN, J., SHANKAR AV, POKHREL RP & AL, E. 1994. Accuracy of estimating food intake by observation. *Journal of American Dietetic Association,* 94**,** 1273-1277.

GORIS, A. & WESTERTERP, K. 1999. Underreporting of habitual food intake is explained by undereating in highly motivated lean women. *Journal of Nutrition,* 129**,** 878-882.

HAARBO, J., A, G., C, H. & C, C. 1991. Validation of Body Composition by Dual Energy X-ray Absorptiometry (DEXA). *Clinical Physiology,* 11**,** 331-341.

HALL, C. & LANE, A. 2001. Effects of rapid weight loss on mood and performance among amateur boxers. *British Journal of sports Medicine,* 35**,** 390-395.

HALL, K., HEYMSFIELD S, KEMNITZ J, KLLEIN S, SCHOELLER D & J, S. 2012. Enery balance and its components. Implications for body weight regulation. *American Journal of Cinical Nutrition,* 95**,** 989-995.

HARRIS, R. 2013. Direct and Indirect Effects of Leptin on Adipocyte Metabolism. *Biochimica et Biophysica Acta, Epub Ahead of Print.*

HIGGINS, J., LASALLE AL, ZHAOXING P & AL, E. 2009. Validation of photographic food records in children are pictures really worth a thousand words? *European Journal of Clinical Nutrition,* 63**,** 1025 - 33.

HILL, C. A. & O'CONNOR, H. O. 1998. Anthropometric profile of professional jockeys. *Paper presented at the Sixth Scientific Conference of International Society for the Advancement of Kinanthrompometry*.

HITCHENS, P., BLIZZARD CL, JONES G, DAY L M & J, F. 2009. The incidence of race-day jockey falls in Australia, 2002-2006. *MJA,* 190**,** 83-86.

HODGES, N., WILLIAMS L, BERRY E, IZADI S, SRINIVASAN J, BUTLER A, SMYTH G, KAPUR N & K, W. 2006a. SenseCam: A Retrospective Memory Aid. *Proc. Ubicomp***,** 177-193.

HODGES, S., WILLIAMS, L., BERRY, E., IZADI, S., SRINVASAN, J., A, B., G, S., N, K. & K, W. 2006b. SenseCam : A retrospective memory aid. *Ubiquitos computing.,* 4206**,** 177-193.

HONGU, N., HINGLE MD, MERCHANT MC, GOING SC & CA, T. 2011. Dietary assessment tools using mobile technology. *Topics in clinical Nutrition,* 26**,** 300-311.

HORSWILL, C. 1993. Weight loss and weight cycling in Amateur Wrestlers: implications for performance and resting metabolic rate. *International Journal of Sport Nutrition.,* 3**,** 245-260.

HRI. 2012. *Guide to Horse Racing* [Online]. Horse racing Ireland. [Accessed].

IHLE, R. & LOUCKS, A. 2004. Dose-response relationship between energy availability and bone turnover in young exercising women. *Journal of bone and mineral research,* 19**,** 1231-1240.

KELLY, P., MARSHALL S, BADLAND H, KERR J, OLIVER M, DOHERTY A & C, F. 2013a. An Ethical Framework for Automated, Wearable Cameras in Health Behaviour Research. *American Journal of Preventive Medicine.,* 44**,** 314-319.

KELLY, P., MARSHALL, S., BADLAND, H., KERR, J., MELODY, O., DOHERTY, A. & FOSTER, C. 2013b. An Ethical Framework for Automated, Wearable Cameras in Health Behaviour Research. *American Journal of Preventive Medicine,* 44**,** 314-319.

KHANNA, N., BOUSHEY CJ, KERR D, M, O., EBERY DS & EJ, D. 2010. An overview of the Technology Assisted Dietary Assessment Project at Purdue University. *Proceedings of the IEEE International Symposium on Multimedia, Taichung, Taiwan***,** 290-295.

KING, M. B. & MEZEY, G. 1987. Eating behavior of male racing jockeys. . *Psychological Medicine,* 17**,** 249-53.

KITAMURA, K., YAMASAKI T & K, A. 2009. Foodlog: Capture,analysis and retrieval of personal food images via web. . *In Proceedings of the ACM multimedia 2009 workshop on Multimedia for cooking and eating activities.* New York.

LABADARIOS, D., KOTZE, J., MOMBERG, D. & KOTZE, T. J. 1993. Jockeys and their practices in South Africa. *World Review of Nutrition and Diet,* 71**,** 97-114.

LEE, H., SMEATON, A. F., JONES, G., DOHERTY, A., GURRIN, C., BLIGHE, M., BYRNE, D. & O'CONNOR, N. E. 2008. Constructing a SenseCam visual diary as a media process. *Multimedia systems,* 14**,** 341-349.

LEYDON, M. & WALL, C. 2002. New Zealand jockeys' dietary habits and their potential impact on health. *International Journal of Sport Nutrition Exercise Metabolism,* 12**,** 220-237.

LOUCKS, A., KIENS B & WRIGHT, H. 2011a. Energy availability in athletes. *Journal of Sports Sciences,* 29**,** S7-S15.

LOUCKS, A. B., KIENS, B. & WRIGHT, H. H. 2011b. Energy availability in athletes. *Journal of Sports Sciences,* 29**,** S7 - S15.

MACDIARMID, J. & BLUNDELL, J. 1998. Assessing dietary intake: Who, what and why of under-reporting. *Nutrition Research Reviews,* 11**,** 231-253.

MAGKOS, F. & YANNAKOULIA 2003. Methodology of dietary assessment in athletes: concepts and pitfalls. *Current opinion in Clinical Nutrition and Metabolic Care,* 6**,** 539-549.

MANORE, M. & THOMPSON, J. 2006. Energy requirements of the athlete. Assessment and evidence of energy efficiency . . *In:* DEAKIN, L. B. A. V. (ed.) *Clinical Sports Nutrition.* New York: McGraw - Hill.

MARR, J. W. & HEADY, J. 1986. Within-and between-person variation in dietary surveys: number of days needed to classify individuals. . *Human Nutrition Applied Nutrition* 40A**,** 347-364.

MCGRATH, C. 2006. Horse Racing: Weight rules are ruining Jockeys' health , says Detorri. *The Independent* 12th April.

MELBY, C., SCHMIDT W & CORRIGAN D 1990. Resting Metabolic rate in weight-cycling collegiate wrestlers compared with physically active, noncycling control subjects. *American Journal of Cinical Nutrition,* 52**,** 409-414.

MERTZ, W., TSUI J C, JUDD JT, REISER S, HALLFRISCH J, MORRIS ER, STEELE PD & LASHLEY E 1991. What are people really eating? The relation between energy intake derived from estimated diet records and intake determined to maintain body weight. *American Journal of Cinical Nutrition,* 54**,** 291-5.

METTLER, S., N, M. & T, K. 2010. Increased protein intake reduces lean body mass loss during weight loss in athletes. *Medicine in Science in Sports and Exercise,* 42**,** 326-337.

MOORE, J., TIMPERIO, A., CRAWFORD, D., BURNS, C. & CAMERON -SMITH, D. 2002. Weight management and weight loss strategies of professional jockeys. *International Journal of Sport Nutrition Metabolism,* 12**,** 1-13.

MORGAN, K., MCGEE H, DICKER P, BRUGHA R, WARD M & E, S. 2009. Slan 2007. Survey of Lifestyles, Attitudes and Nutrition in Ireland, Alcohol use in Ireland: A profile of drinking patterns and alcohol-related harm from SLAN 2007. Dublin: Department of Health and Children.

NATTIV, A., LOUCKS, A., MANORE, M., SUNBORN , C., SUNDGOT-BORGEN, J. & WARREN, M. P. 2007. " The Female Athlete Triad : The ACSM Position Stand. *Medicine in Science in Sports and Exercise,* Special communication 1867-1882.

O'LOUGHLIN, G., CULLEN SJ, MCGOLDRICK A, O'CONNOR S, BLAIN R, O'MALLEY S & WARRINGTON, G. 2013. Using a Wearable Camera to Increase the Accuracy of Dietary Analysis. *The American Journal of Preventive Medicine,* 44**,** 297-301.

OPPLIGER, R. A., CASE H, HORSWILL C, LANDRY G L & SHELTER A C 1996. Position stand: Weight loss in wrestlers. . *Medicine in Science in Sports and Exercise,* 28**,** 9-12.

PASIOKAS, S., KELLOGG C, KRAMER F & H, L. 2011. Appetite and Endocrine Regulators of Energy Balance after 2 days of Energy Restriction: Insulin, Leptin, Ghrelin and DHEA-S. . *Obesity,* 19**,** 1124-1130.

PHILLIPS, S. & VAN LOON, J. 2011a. Dietary protein for athletes: From requirements to optimum adaption. *Journal of Sports Sciences,* 29**,** S29-S38.

PHILLIPS, S. M. & VAN LOON, L. J. C. 2011b. Dietary protein for athletes: From requirements to optimum adaptation. *Journal of Sports Sciences,* 29**,** S29-S38.

POSLUSNA, K., RUPRICH J, DE VRIES J H, M, J. & P, V. T. V. 2009. Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. *British Journal of Nutrition,* 101**,** S73-85.

PROTEAU, S., PELLE A, COLLOMP K, BENAHAMOU L & D, C. 2006. Bone density in elite judoists and effects of weight cycling on bone metabolic balance. *Medicine in Science in Sports and Exercise,* 38**,** 694-700.

REBRO, S. M., PATTERSON R E, KRISTAL A R & L, C. C. 1998. The effect of keeping food records on eating patterns. *Journal of the American Dietetic Association,* 98**,** 1163-1165.

ROSENBLATT, R. 2008. Jockeys are still battling weight issues. *The Associated Press*, Tuesday 29th April 2008.

RUTISHAUSER, I. 2005. Dietary intake measurements. *Public Health Nutrition,* 8**,** 1100-1107.

SAWKA, M. N., BURKE LM, EICHNER R, MAUGHAN R, MONTAIN S J & STACHENFELD N S 2007. Position stand: Exercise and fluid replacement *Medicine in Science in Sports and Exercise,* 39**,** 377-390.

SCHEINEMANN, J. 2005. Jockey dies after riding at Colonial Downs. *Washington Post*.

SCHOELLER, D. 1995. Limitations in the Assessment of Dietary Energy Intake by Self-Report. *Metabolism,* 144**,** 18-22.

SCHWARTZ, J. & BYRD BREDBENNER, C. 2006. Portion distortion: typical portion sizes selected by young adults. *Journnal American Dietetic Association,* 106**,** 1412-8.

SIX, B., SCHAP TE, ZHU FM & ET AL 2010. Evidence based development of a mobile telephone food record. *Journnal American Dietetic Association,* 110**,** 74-79.

SLATER, G., RICE AJ, T. R., SHARPE, K., JENKINS, D. & HAHN, A. G. 2005. Impact of Acute Weight Loss and/or Thermal Stress on Rowing Ergometer Performance. *Medicine in Science in Sports and Exercise,* 37**,** 1387 - 1394.

SMATHERS, A., BEMBEN M G & BEMBEN D A 2009. Bone denisty comparisons in male competitive road cyclists and untrained controls. *Medicine in Science in Sports and Exercise,* 41**,** 290-296.

STEEN, S., OPPLIGER R A & KD, B. 1988. Metabolic effects of repeated weight loss and regain in adolescent wrestlers . *Journal of American Dietetic Association,* 260**,** 47-50.

SUBAR, A., KIPNIS V, TROIANO RP & AL, E. 2003. Using intake biomarkers to evaluate teh extent of dietary misreporting in a larg sample of adults. The OPEN study. *American Journal of Epidemiology,* 158**,** 1-13.

SUDI, K., K, O., PAYERL, D., BAUMGARTL, P., TAUSCHMANN, K. & MULLER, W. 2004. Anorexia Athletica. *Journal of Nutrition,* 20**,** 657-661.

SUN, M., FERNSTROM JD, JIA W, HACKWORTH S, YAO N, LI Y, LI C, FERNSTROM M & R, S. 2010. A Wearable Electronic System for Objective Dietary Assessment. *Journal of American Dietetic Association,* 110**,** 2-6.

SUNDGOT-BORGEN, J. & GARTHE, I. 2011. Elite athletes in aesthetic and Olympic weight-class sports and the challenge of body weight and body composition. *Journal of Sports Sciences,* 29**,** S101-S114.

SUNDGOT-BORGEN, J. & TORSTVEIT, M. 2004. Prevelance of eating disorders in elite athletes is higher than in the general poulation. *Clinical Journal of Sports Medicine,* 14**,** 25-32.

TARNAPOLSKY, M. 2006. Protein and amino acid needs for training and bulking up *In:* DEAKIN, L. B. V. (ed.) *Clinical sports nutrition.* 3rd ed. New York: McGraw Hill.

THOMAS, B. & BISHOP, J. 2007. Dietary Assessment in Manual of Dietetic Practice. *Fourth Edition.* Oxford: Blackwell Publishing.

THOMPSON, F., SUBAR AF, LORIA CM & J, R. 2010. Need for Technological Innovation in Dietary Assessment. *Journal of American Dietetic Association,* 110**,** 48-51.

WALBERG RANKIN 2006. Making weight in sports. *Clinical sports nutrition.* 3rd ed. Maidenhead: McGraw-Hill professional.

WALBERG RANKIN, J. 2010. Making weight in sports. *In:* DEAKIN, L. B. V. (ed.) *Clinical Sports Nutrition.* Sydney: McGraw-Hill.

WALDRON-LYNCH, F., MURRAY B F, BRADY J J, MCKENNA M J, MCGOLDRICK A, O'LOUGHLIN G & BARRAGY J M 2010. High bone turnover in Professional Jockeys. *Osteoporosis International* 21**,** 521-525.

WARRINGTON, G., DOLAN, D., MCGOLDRICK, A., MCEVOY, J., C, M., M, G. & AL, E. 2009. Chronic weight control impacts on on physiological function and bone health in elite jockeys. *Journal of Sports Sciences,* 27**,** 543-550.

WHELTON, H., HARRINGTON, J., CROWELY, E., KELLEHER, V., CRONIN, M. & PERRY, I. J. 2007. Prevelance of Overweight and Obestiy on the Island of Ireland. Results from the North South Survey of Children's Height, Weight and Body Mass Index, 2002. *BMC Public Health,* 7.

WILSON, G. 2012. An Alternative Dietary Strategy to Make Weight While Improving Mood, Decreasing Body Fat, and Not Dehydrating: A Case Study of a Professional Jockey. *International Journal of Sport Nutrition and Exercise Metabolism Eating Disorders,* 22**,** 225-231.

WILSON, G., SPARKS, A., DRUST, B., MORTON, J. P. & CLOSE, G. L. 2013. Assessment of energy expenditure in elite jockeys during simulated race riding and a working day: implications for making weight. *Applied Physiology, Nutrition, and Metabolism,* 38**,** 415-420.

ZHU, F., BOSCH M, WOO I, KIM S, CJ, B., EBERT DS & DELP EJ 2010. Theuse of Mobile Devices in aiding dietary assessment and evaluation. *IEEE Journal of Selected Topics in Signal Processing,* 4**,** 756-766.

Appendices

Appendix 1

Plain Language Statement:

The title of this study is: **A comparison and validation of calorie intake using a standard food diary and the SenseCam.**

This study is being carried out by a student of The School of Human Health and Performance in Dublin City University, Glasnevin.

The principal investigator is Gillian O' Loughlin (gillian.oloughlin3@mail.dcu.ie)

Participants will be required to commit themselves to 24 hours of monitoring. This will be done by reviewing their food intake with the use of a one day food diary. In addition to this they will be asked to wear a SenseCam (a wearable camera which automatically takes a photo every 30 seconds and also when it detects movement). Participants will be asked to take special care of this camera and charge its battery if necessary. Apart from the 24 hours in question, participants will also be asked to meet with the researcher to receive instruction on how to use and charge the camera. All information of participants is confidential and will be kept that way. All data collected will only be available to the main investigators and stored securely in Dublin City University.

Participants may see potential benefits from information gained about their food intake and thus make changes to their eating habits. All participation in this study is on a voluntary basis and no participants are under any obligation to participate should they feel uncomfortable with any aspect of the study. Participants can opt out of this study at any time without penalty or consequence.

If participants have concerns about this study and wish to contact an independent person, please contact: The secretary, Dublin City University Research Ethics Committee, c/o Office of the Vice President for Research, Dublin City University, Dublin 9, Tel: 01 70

Appendix 2

RACE trainee consent form

Name of participant:	
Address of participant:	
Telephone no:	
Date of birth of participant:	

I consent to take part in the study outlined. I understand that participation in this study is voluntary and that I may withdraw from the Research Study at any point. I have read and understood the information in this form.

Signed: ___________________________

Date:__________________________

Participant

Required for those under 18 years of age

I confirm that I am the parent/guardian of the participant and that I am authorised to sign this consent form on behalf of the participant as well as on my own behalf.

Signed: ___________________________ Date:

Parent/Guardian

Appendix 3

Dublin City University

Informed Consent Form

Dear Parent

As part of ongoing research between RACE/The Turf Club and Dublin City University your son has been asked to take part in a study which aims to, accurately, assess what jockeys eat. This will be done using a small camera called a 'SenseCam', worn on the chest (on the outside of clothing) for 1 day. The participant will also be asked to keep a food diary for the same day. The information from both the camera and the diary will be analysed and used to help develop specific nutritional advice for all jockeys. All information is strictly confidential.

As your son is under 18 years of age, parental/guardian consent is required. If you are happy for your son to take part in the study please complete and return the form attached, to RACE.

If you have any queries regarding the above please contact either Gillian O'Loughlin (Dietitian) 087 412xxxx

Yours Sincerely

____

Gillian O'Loughlin (Turf Club Dietitian)

Appendix 4

Instructions for using the camera

1. Strap the camera around your chest, quite high up, once you are dressed.

2. Press down on the round button on top of the camera until the green light comes on.

3. Try to keep the camera on all day except when showering or racing.

4. Try not to cover the camera e.g. under jacket etc.

5. Take the camera off last thing at night and switch it off by pressing down on the round button until the lights go out.

6. I will collect the camera and diary the following day.

Thank you for taking part in the study.

Any queries call me on 087 xxxxxx.

Appendix 5

Your 1 Day Food Diary

All information is kept confidential and is not shared with others.

Today's Date: __________

Name: ____

Address: ____

Your Age: _________ Date of Birth: ____________

Height: _________ Weight: ________

Lightest weight required for rides __________

Do you take a vitamin/ mineral supplement? ☐ Yes ☐ No

Checklist:

- Remove all electrical devices before showering or using the sauna
- Put the camera on charge overnight and remember to wear it in the morning.
- Remember to fill out the food and activity diary as you go along.
- HELPLINE: if you have any problems with the equipment or are unsure what to do you can contact me on 087 412xxxx at any time.

Please follow these instructions carefully when completing your food diary.

- Make a note of everything you eat and drink for 1 non racing day.
- Keep to your normal routine. Do not change your diet while keeping the food diary.
- If possible fill in the meals, snacks and drinks immediately after eating/drinking them.
- Record the approximate time of eating.
- Fill in as much detail as possible, if you know the weight of any foods then note it in the diary.
- Be honest when filling out the diary.
- The information received will be kept confidential.

Tips for accurately filling out your diary.

- Note whether food is boiled, fried, stewed, grilled, baked, steamed or cooked in the microwave.
- State the brand name of all foods e.g. Kellogg's cornflakes etc.
- Make sure to include all drinks and state if sugar and milk are added.
- Include all foods and snacks even if it is just a handful of crisps or sweets. Also include any alcohol consumed.

Helpful Hints

- **Bread:** State if brown, white, wholemeal, plain or soda bread.
- **Milk:** Whole, low fat, super or skimmed milk.
- **Cheese:** Cheddar, Edam, Mozzarella, cottage cheese or low fat Cheddar cheese etc.
- **Fruit:** Peeled or unpeeled, whole fruit or fruit juice, tinned in syrup or natural juice.
- **Meat**: State the cut of meat and if fat is eaten e.g. rind on Bacon, crackling on pork etc.
- **Fish:** Cod, Whiting, Trout or Salmon etc.(tinned, frozen, Coated in breadcrumbs or batter)
- **Chicken:** Leg, wing, breast or white meat only and whether the

skin was eaten or not.

- **Butter/Spread:** State the brand and if you spread it thinly or thickly.
- **Biscuits:** Name the brand and if chocolate covered.
- **Sweets:** Give the brand name and size or weight.
- **Sauces/gravy:** Record the amount eaten and the brand name e.g. 2 tablespoons of bisto gravy.
- **Soft drinks:** Give the brand name and if diet or not.
- **Ready prepared Meals:** Please give as much information as possible example; *Tesco's Chicken Kiev, 220g oven baked.*
  - **Takeaways:** If possible state what and where you purchased the food example; *Big Mac at McDonald's, Large chips from local chipper.*

Food & Drink Diary

Name: ___________________ Age _______ Flat ☐ National Hunt ☐

Day 1	Race day ☐ Non race day ☐	Date:	
Time	Food/Drink/Snack	Quantity	