SELMA COELHO LIBERATO

ATIVIDADE FÍSICA, PADRÃO DIETÉTICO E COMPOSIÇÃO CORPORAL DE ADULTOS JOVENS AUSTRALIANOS: CARACTERIZAÇÃO E COMPARAÇÃO DE MÉTODOS

Tese apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Ciência e Tecnologia de Alimentos, para obtenção do título de *Doctor Scientiae*

VIÇOSA
MINAS GERAIS – BRASIL
2005

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APROVADA: 30 de junho de 2005

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(Orientadora)

Dedico ao meu avô José Coelho da Silva (1899 – 1974), *in memoriam*, graduado na primeira turma do curso de Tecnologia Agrícola da Universidade Federal de Viçosa, em 1929.

AGRADECIMENTOS

A Deus, por ter me abençoado e me dado forças para desenvolver o curso de doutorado.

À Universidade Federal de Viçosa, pela oportunidade de realização do curso.

Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) pela concessão das bolsas de estudo nacional.

À professora Josefina Bressan Resende Monteiro pela confiança, orientação e incentivo à realização do estágio de doutoramento no exterior.

Ao professor Andrew Hills e Nuala Byrne da School of Human Movement Studies, Faculty of Health, Queensland University of Technology pelos ensinamentos e orientação nos trabalhos desenvolvidos.

À professora Jan Payne, da School of Health, Faculty of Health, Queensland University of Technology, Queensland University of Technology, pelos ensinamentos.

À professora Fátima Magalhães de Almeida pela amizade, ensinamentos, incentivo e exemplo de luta contra os obstáculos da vida.

À professora Neuza Maria Brunoro Costa pela amizade, apoio constante, críticas e sugestões.

Aos professores João Carlos Bouzas Marins e Silvia Eloiza Priore pelas críticas e sugestões.

Ao coordenador da pós-graduação em Ciência e Tecnologia de Alimentos, professor Nélio José de Andrade, pelo apoio ao estágio de doutoramento no exterior.

Ao colega de curso Paulo Roberto Amorim pela amizade, convivência e valiosa ajuda na coleta de dados durante os testes cárdio-respiratórios.

Aos colegas de curso Denise Machado Mourão, Dina Maria Medem, Maria do Socorro Bastos e Paulo Rogério Fontes, da Universidade Federal de Viçosa, e Raymond

Li, Rachel Colley, Darren Roffey, Rebecca Roodveldt e Kathryn Jackson, da Queensland University of Technology, pela agradável convivência e estímulo.

Aos técnicos da School of Human Movement Studies, Faculty of Health, Queensland University of Technology, Connie Wishart e Jarrod Meerkin, pela ajuda na coleta de dados.

À secretária da pós-graduação do curso de Ciência e Tecnologia de Alimentos, Maria Geralda Campos da Costa, e às secretárias da School of Human Movement Studies, Faculty of Health, Queensland University of Technology, Elaine Rose Clark, Radka Preclikova e Pamela Smith pelo ajuda prestada e agradável convívio.

À equipe da Coordenadoria de Educação Aberta e a Distância (CEAD), da Universidade Federal de Viçosa, e ao técnico Dennis Clark, da Queensland University of Technology, que viabilizaram tecnicamente a defesa da tese por videoconferência.

A todos os demais professores que contribuíram para o meu crescimento profissional, em especial à professora Helena Maria Pinheiro Sant'Ana, Valéria Paula Rodrigues Minim, Afonso Mota Ramos, José Benício Paes Chaves e Carlos Arthur Barbosa da Silva.

A todos os funcionários do Setor de Nutrição do Hospital Antônio Bezerra de Farias, em especial às amigas Maria Auxiliadora de Souza Murari, Márcia Hélida Furrechi e Karla Rodrigues Fardin Pavan, pelo incentivo e pela amizade.

À minha avó, D. Dalila Andrade Resende Coelho, pelo apoio, incentivo e orações diárias.

Aos meus pais, José Fernando Coelho da Silva e Maria do Socorro Lira Coelho, pelo apoio e incentivo durante o curso.

Ao meu esposo, José Ricardo, e aos meus filhos, Marina e Matheus, pelo incentivo, apoio, paciência, compreensão e amor.

A todos os demais que, direta ou indiretamente, contribuíram para a realização deste trabalho.

BIOGRAFIA

SELMA COELHO LIBERATO, filha de José Fernando Coelho da Silva e Maria do Socorro Lira Coelho, nasceu em Viçosa, Minas Gerais.

Em 1990, graduou-se engenheira-agrônomo pela Universidade Federal de Viçosa (UFV) e, no mesmo ano, iniciou o curso de Nutrição na UFV, concluindo-o em dezembro de 1992.

Em 1993 e 1994, trabalhou no Hospital Fundação Rio Doce, em Linhares, como nutricionista responsável pelo Serviço de Alimentação e Dietoterapia.

Em outubro de 1994, mediante aprovação no concurso, foi contratada como nutricionista do IESP, Instituto Estadual de Saúde Pública, para atuar no hospital Antônio Bezerra de Faria.

Em fevereiro de 2001, concluiu o mestrado em Agroquímica pela Universidade Federal de Viçosa.

Em abril de 2001, iniciou o curso de doutorado em Ciência e Tecnologia de Alimentos pela Universidade Federal de Viçosa. Entre janeiro de 2004 e março de 2005, esteve na Queensland University of Technology, Brisbane, Austrália, para desenvolver o projeto de pesquisa referente ao curso de doutorado.

LISTA DE ABREVIAÇÕES

24hDR = 24-hour dietary recall

4dFR = 4-day food record

AI = adequate intake

AR = Acceptable reports

BMC = bone mineral content

BMI = body mass index

BMR = basal metabolic rate

B-PAR = Bouchard physical activity record

C = continuation of the lateral sides of the rib cage

CO_2 = carbon dioxide production

CVD = cardiovascular disease

CV_{wB} = coefficient of variation of BMR measurements

CV_{wEE} = within –participant variation in EE

CV_{wEI} = within-participant variation in EI

CV_{tP} = total variation in PAL

d = number of days of diet assessment

DEXA = dual-energy X-ray absorptiometry

EAR = estimated average requirement

EE = energy expenditure

EI = energy intake

FFM = fat free mass

HDL-C = high-density lipoprotein cholesterol

HR = heart rate

IMC = índice de massa corporal

L = lumbar vertebrae

LDL-C = low-density lipoprotein cholesterol

MET = metabolic equivalent

MUFA = monounsaturated fatty acids

NHFA = National Heart Foundation of Australia

NHMRC = National Health and Medical Research Council

O_2 = oxygen consumption

PA = physical activity

PAEE = physical activity energy expenditure

PAL = physical activity level

PUFA = polyunsaturated fatty acids

RDA = recommended dietary allowance

RER = respiratory exchange ratio

RMR = resting metabolic rate

RT3 = triaxial accelerometer TriTrac-RT3™

S = coefficient of variance for EI, BMR and energy requirements

T = any trunk soft tissue

TC = total cholesterol

TG = triglycerides

UL = upper limit

UR = under-reporters

VM = vector magnitude

VO_{2max} = maximal oxygen uptake

VO_{2peak} = VO_2 peak oxygen uptake

WHO = World Health Organization

WHR = waist hip ratio

ÍNDICE

RESUMO

LIBERATO, Selma Coelho, D.S. Universidade Federal de Viçosa, junho de 2005. **Atividade física, padrão dietético e composição corporal de adultos jovens australianos**: **caracterização e comparação de métodos**. Orientadora: Josefina B. Resende Monteiro. Conselheiros: Valéria Paula Rodrigues Minim e Silvia Eloiza Priore.

Foram conduzidos três estudos em Brisbane, Austrália. Os participantes foram selecionados ao acaso e o único critério de inclusão no estudo era que fossem homens saudáveis entre 18 e 25 anos. A maioria era estudante universitário. No primeiro estudo, com o objetivo de avaliar a acurácia em estimar o gasto energético e os padrões de atividade física sob condições de vida livre, o diário de atividade física (B-PAR) foi comparado com o acelerômetro triaxial RT3 em 11 participantes durante 4 dias consecutivos. No segundo estudo foram comparados dois métodos de consumo alimentar: recordatório alimentar de 24 horas (24hDR) e o diário alimentar de quatro dias (4dFR) em 34 participantes. Também foi possível quantificar a subestimação do consumo alimentar, estimada por 24hDR e 4dFR, comparado ao gasto energético e avaliar a acurácia do método de Goldberg para identificar subestimação. No terceiro estudo, para diagnosticar e adotar medidas corretas de intervenção para tentar reduzir a obesidade e as doenças cardiovasculares, foram avaliadas em 38 participantes: composição corporal por meio de medidas antropometricas, pregas cutâneas e absortometria de raios X de dupla energia (DEXA); taxa metabólica basal (RMR) por meio de calorimetria indireta, padrão de lipídios sanguíneos, consumo alimentar por meio de 4dFR, padrão de atividade física por meio de B-PAR e o fitness cardiorespiratorio por meio de teste direto da capacidade máxima. No primeiro estudo, o gasto energético foi superestimado em 14,7% pelo B-PAR em relação ao acelerômetro RT3. As limitações do método de B-PAR e a falta de comprometimento com o estudo

contribuíram para a superestimativa do gasto energético pelo B-PAR. O preenchimento de um diário de atividade física enquanto usando o acelerômetro permitiu constatar que, quando fazendo atividade física intensa, algumas vezes os participantes tiraram o acelerômetro. No segundo estudo, houve boa concordância no consumo de macronutrientes estimado por 24hDR e 4dFR em nível de grupo mas não em nível individual. Em nível de grupo, tanto obesos quanto não obesos subestimaram consumo alimentar. Em nível individual, 20,6% e 8,8% dos participantes subestimaram consumo energético por 4dFR e 24hDR, respectivamente considerando o critério do limite de confiança de 95% para consumo energético em relação ao gasto energético. A sensibilidade e especificidade do método de Goldberg foram 0,86 e 0,93, respectivamente para 4dFR. Para o 24hDR, essesvalores foram 1,00 e 0,90, respectivamente. A ausência de diferença no consumo de macronutrientes expressos como percentagem de energia entre os relatos aceitáveis e aqueles que subestimaram o consumo de alimentos sugere que os dados do presente estudo podem ser usados em análises com outras variáveis na evolução da relação entre dieta e saúde, desde que expressos em valores energéticos. Dos participantes deste estudo, 10,5% foram abaixo do peso (índice de massa corporal, IMC < 20 $kg.m^{-2}$), 47,4% saudáveis (20 IMC 24,9 $kg.m^{-2}$), 31,6% sobrepeso (25 IMC 29,9 $kg.m^{-2}$) e 10,5% obesos (IMC 30 $kg.m^{-2}$). Quando mensurada por DEXA, a gordura corporal dos participantes variou de 6,0 a 37,0%. Obesos e não obesos tiveram similar massa livre de gordura e conteúdo mineral ósseo. Mais de 70% do conteúdo mineral ósseo e mais de 80% da massa livre de gordura estão localizados nos braços e pernas. O RMR dos obesos também foi similar ao dos não obesos, provavelmente devido a similar quantidade de massa livre de gordura. O consumo médio de gorduras e carboidratos dos participantes do corrente estudo estive acima (32,3%) e abaixo (47,1%), respectivamente do recomendado (30% e 50%, respectivamente). O consumo de ácidos graxos poliinsaturadas (13,4 $g.d^{-1}$) e fibras (25,8 $g.d^{-1}$) esteve abaixo do recomendado (18,6 $g.d^{-1}$ e 38 $g.d^{-1}$, respectivamente). O consumo de quase todas as vitaminas e minerais esteve entre a recomendação (RDI) e o limite superior (UL). Somente o consumo de niacina esteve acima da UL (35 $mg.d^{-1}$). Em média, o tempo gasto em atividades moderadas e intensas pelos participantes foi 140,4 minutos. Obesos gastaram mais tempo fazendo atividades moderadas e intensas que não obesos. O nível de fitness cardiorespiratório foi excelente para os não obesos (55 $ml.kg^{-1}.min^{-1}$) e na media para os obesos (44 $ml.kg^{-1}.min^{-1}$) comparado aos valores publicados pela American College of Sports Medicine (> 51 $ml.kg^{-1}.min^{-1}$ e de 42 a 48

$ml.kg^{-1}.min^{-1}$, respectivamente). Aumentando a atividade física e tendo uma dieta saudável e balanceada pode aumentar a massa corporal magra, a qual aumenta a taxa metabólica basal. Uma maior taxa metabólica basal contribui para um maior gasto energético, o qual contribui para um desbalanço entre gasto energético e consumo alimentar no sentido de perder peso e conseqüentemente reduzir a obesidade. Além de colaborarem com a redução da obesidade, o aumento da atividade física e uma dieta saudável também podem estar colaborando com a melhora dos padrões de lipídio sanguíneo, onde 68% dos participantes tiveram colesterol total acima dos limites recomendados (4,0 $mmol.L^{-1}$). Medidas combinadas podem resultar em maiores benefícios para a saúde que medidas isoladas.

ABSTRACT

LIBERATO, Selma Coelho, D.S. Universidade Federal de Viçosa, June of 2005. **Physical activity, dietary patterns and body composition of Australian young men: characterization and comparisons of methods**. Adviser: Josefina B. Resende Monteiro. Committee members: Valéria Paula Rodrigues Minim and Silvia Eloiza Priore.

It was conducted three studies in Brisbane, Austrália. The participants were selected at random and the only inclusion criteria into the studies was to be health men aged 18 to 25 y. The most was university students. On the first study, with the goal of evaluating the accuracy in estimating daily energy expenditure and in characterizing the PA patterns of free-living human, the physical activity diary (B-PAR) data were compared with RT3 accelerometer data in 11 participants over 4 consecutive days. On the second study, It was compared two methods of EI assessment: 24-hour dietary recall (24hDR) and 4-day food record (4dFR) in 34 participants. It was also possible to assess the underreporting of food intake assessed by 24hDR and 4dFR, compared to EE and to evaluate the accuracy of the Goldberg cut-off method for identifying underreporting. On the third study, to identify and adopt the correct interventions to try to decrease obesity and cardiovascular diseases it was assessed in 38 participants: body composition by anthropometric measurements, skinfols and dual-energy X-ray absorptiometry (DEXA); resting metabolic rate (RMR) by indirect calorimetry, blood lipid pattern, food intake by 4dFR, physical activity pattern by B-PAR and cardiovascular fitness by direct measurement of maximum oxygen capacity. The energy expenditure was overestimated in 14.7% by B-PAR in relation to RT3 acceleromenter. The B-PAR limitations and the lack of participants' commitment contribute to EE overestimated by B-PAR in relation to RT3. Recording PA while wearing accelerometer allows us realize that the

participants took off the accelerometer in most of the time for doing intense PA. There were good agreement between the measurements of energy and macronutrients intake by 24hDR and 4dFR at the group level, but not at the individual level. At the group level, obese and non-obese groups underreported EI by both 4dFR and 24hDR methods. At the individual level, 20.6% and 8.8% of participants underreported their EI by 4dFR and 24hDR, respectively considering the 95% confidence interval for EI / EE criteria. The sensitivity and specificity of Goldberg cut-off method were 0.86 and 0.93, respectively for 4dFR. For 24hDR, the corresponding values were 1.00 and 0.90, respectively. The absence of difference significant between macronutrients intake expressed in energy percentage of acceptable reporters and that of under-reporters found in the current study suggest that the diet data can be used in analysis with other variables in the evaluation of the relation between diet and health, since macronutrients are expressed in energy values. From the participants of the current study, 10.5% were classified as underweight (body mass index, BMI < 20 kg.m^{-2}), 47.4% as healthy range (20 BMI 24.9 kg.m^{-2}), 31.6% as overweight (25 BMI 29.9 kg.m^{-2}) and 10.5% as obese (BMI 30 kg.m^{-2}). When assessed by DEXA, the body fat of participants of the current study ranged from 6.0 to 37.0%. Obese and non-obese men had similar fat free mass and bone mineral content. More than 70% of bone mineral content and more than 80% of fat free mass are on leg and trunk together. The RMR of obese men was similar to those of non-obese had likely due to similar amount of fat free mass. The mean intake of fat and carbohydrate of the participants of the current study were above (32.3%) and below (47.1%), respectively, to the recommendation (30% and 50%, respectively). The mean polyunsaturated fatty acids (13.4 g.d^{-1}) and fiber intake (25.8 g.d^{-1}) were lower than the recommended value (18.6 g.d^{-1} and 38 g.d^{-1}, respectively). The intake of almost all vitamins and minerals was between recommendation (RDI) and the upper limit (UL). Only the niacin intake was above the UL (35 mg.d^{-1}). An overall, the mean time spent in moderate and intense activity, was 140.4 min. Obese spent more time doing moderate and intense physical activity than non obese men. However, to some participants who are not spending the recommended minimum time, more physical activity of moderate and or intense level should be recommended. The level of fitness was excellent for non-obese men (55 ml.kg^{-1}.min^{-1}) and at average for obese (44 ml.kg^{-1}.min^{-1}) compared with values published by American College of Sports Medicine (> 51 ml.kg^{-1}.min^{-1} and of 42 to 48 ml.kg^{-1}.min^{-1}, respectively). Increasing PA and having a healthy and well balanced diet may help to increase FFM which increase

RMR. A higher RMR accounts for a higher EE which would account for an imbalance between EI and EE in order to lost weight and therefore to decrease the obesity. Besides to contribute to decrease obesity, increased physical activity and healthy diet may also be contributing to improve the blood lipid pattern, as 68% of the participants had total cholesterol above the recommended limits (4.0 $mmol.L^{-1}$). Combined measurements can result in greater help than isolated measurements.

GENERAL INTRODUCTION

Cardiovascular disease is a leading cause of global mortality, accounting for almost 17 million deaths annually, that means 30% of all deaths worldwide (Bonow *et al.*, 2002; Smith *et al.*, 2004). The explosive increase in the prevalence of obesity with its related complications of hypertension, hyperlipidemia and atherosclerotic vascular disease is accelerating rate of cardiovascular disease (Bonow *et al.*, 2002). According to World Health Organization (WHO, 2002), an estimated 1 billion people across the world are now overweight or obese and 18 million children under the age of 5 are overweight and these children are at an increased risk of developing dyslipidemia and hypertension as early as their teen years (Bonow *et al.*, 2002). Data from a national sample of 11247 Australians aged 25 years examined in 2000 revealed that 59.8% of Australian adults were considered to be either overweight (Body Mass Index (BMI) of 25.0 – 29.9 $kg.m^{-2}$) or obese (BMI 30.0 $kg.m^{-2}$), with one third of them (20.8% overall) falling into the obesity category. Amongst male subjects 48.2% and 19.3% were considered to be overweight and obese, respectively (Dalton *et al.*, 2003).

Obesity develops when a chronic quantitative imbalance exists between energy intake (EI) and energy expenditure (EE), which include three components: a) the basal metabolic rate (BMR), which typically accounts for about 60 to 70% of total EE, represents the minimal rate of EE that is necessary to support vital functions such as the work of breathing, circulation of blood, maintenance of body temperature, etc; b) the thermic effect of food or dietary thermogenesis represents the EE for eating, digesting, absorbing, transporting, metabolizing, and storing useable forms of energy derived from food and generally represents about 10% or total EE; and, c) EE on physical activity (PA) which is the most variable (Keim *et al.*, 2004). To unbalance the energy equation in the direction of weight gain requires increasing EI, decreasing PA, or altering both simultaneously. The human body has some ability to regulate energy in that EI can be adjusted to EE and vice versa. However, this ability is not sufficient to completely counter the effects on EI, and a chance in body mass results. The rapid increase in the prevalence of obesity through the world suggests that the environment factors are exerting constant pressure to increase EI and decrease EE.

The relationship of obesity not only with diet patterns but also with physical activity have been investigated by many papers, but scarce are the papers where both sides, energy intake and physical activity, were investigated with obesity in the same study. The aim of this study was to investigate the relationship between diet pattern, physical activity, fitness, body composition, resting metabolic rate and lipids levels in young men.

In one previous study, it was evaluated the accuracy of the physical activity records on estimating daily EE and on characterizing the PA patterns of free-living humans, the Bouchard physical activity record data were compared with RT3 accelerometer data, which it is the single objective method enabling for assessment the intensity and duration of PA, as well of EE, throughout the day. Eleven men aged 18 to 25 y, recruited at random worn RT3 consisting with completing Bouchard physical activity record over 4 days.

In another previous study, dietary pattern two methods of food intake assessment: 24-hour dietary recall (24hDR) and 4-day food record (4dFR) were compared in 34 youth men selected at random. In addition the underreporting was assessed compared to EE. It was evaluated the accuracy of the Goldberg cut-off method for identifying underreporting.

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CHAPTER 1

COMPARISON BETWEEN THE BOUCHARD PHYSICAL ACTIVITY RECORD AND THE TRITAC-RT3 ACCELEROMETER FOR MEASURING ENERGY EXPENDITURE AND PHYSICAL ACTIVITY INTENSITY

INTRODUCTION

Through a variety of physiological, metabolic and psychological mechanisms, habitual physical activity (PA) has been shown to impact significantly on chronic disease (AIHW, 1999). Research to date has resulted in generation guidelines regarding the volume of PA sufficient to impact on health status (Lee and Meyers, 1997; Williams, 2001; Kruger *et al.*, 2005). In order to determine the optimal dose of PA to modify disease risk, the volume intensity of daily PA and energy expenditure (EE) needs to be assessed.

Motion sensors range in complexity, sensibility and cost from the relatively simple pedometer to the triaxial accelerometer capable of detecting movements in one axis, and triaxial in three axes. Motion sensors are relatively inexpensive and portable electronic devices that measure body movements and may estimate EE, intensity and duration of PA. Pedometers, the simplest motion sensors, have limited use in estimate EE as they detect simply record steps taken by an individual. In contrast, accelerometers may record movements in one (uniaxial) or three (triaxial) planes. Descriptions of each motion sensor, including reviews of evaluation and reliability studies, are available elsewhere (Conn *et al.*, 2000; Welk, 2002; Ainslie *et al.*, 2003). Accelerometers have capacity to store a considerable volume subjectivist analysis, which may provide detailed information regarding the PA patterns of an individual over a number of days. Another advantage of the device is that the data can not be manipulated by participants.

Commercially available accelerometers provide similar information but differ in amount of memory, software capabilities, type, size and sensitivity of the sensor (Welk, 2002). The development of the triaxial accelerometer was described in detail by Bouten *et al.* (1997). The TriTrac-R3D™, a triaxial accelerometer, has been available since 1990s (Welk and Corbin, 1995) and used in numerous studies despite being cumbersome in size and potential to obstruct movement when worn properly (King *et al.*, 2004). The latest version's TriTrac-RT3™ (RT3) is approximately one-third the size of the TriTrac-R3D, is easier to wear and has a sampling interval of 1 s to 1 min. Depending on its mode of operation, the device undertaking can record data for up to 21 d, which are then downloaded to a PC for display and statistical processing. The RT3 has been successfully evaluated against oxygen uptake in both children and adults, over a range of regulated and nonregulated activities (Powell *et al.*, 2003; Rowlands *et al.*, 2004).

Individuals expend different quantities of energy in the same PA. Moreover, individuals show considerable variability in their resting metabolic rate (RMR) due to differences in genetic characteristics, fat free mass, body weight, age, gender, and health conditions. Therefore, besides the total EE (expressed as $kcal.d^{-1}$ or $MJ.d^{-1}$), it is necessary to express EE as a unit that enables the comparison among individuals or populations and the study of the PA behaviour. EE on PA is often expressed in metabolic equivalents (MET), with specific PA expressed as multiples of the energy cost of rest (MET = EE / RMR). One MET is defined as the EE when sitting quietly, the average in adults being 1 $kcal.kg^{-1}.h^{-1}$. The MET is used as an index of the intensity of PA (Schutz *et al.*, 2001), ranging from 0.9 to 18 (light to intense) to represent specific PA. A compendium of PA and corresponding MET values has been published by Ainsworth *et al.* (1993; 2000), which enables the comparison among adults assuming no handicaps or other conditions that would significantly alter their mechanical or metabolic efficiency. The MET provides a convenient option to express and energy needs of a wide range of people in a standardized form (Pannemans *et al.*, 1995). The FAO/WHO/UNU (1985) expert committee on energy requirements expressed the energy needs of adults as multiples of RMR (i.e. MET). Individual PA are commonly reported as total daily EE and as minutes spent doing PA, which are commonly classified in three intensity categories proposed by Pate *et al.* (1995): light (EE < 3

MET), moderate (3 EE < 6 MET), and high (EE 6 MET). Although many authors have used this classification (Hendelman *et al.*, 2000; Schmidt *et al.*, 2003; Cradock *et al.*, 2004), a number of categories and MET thresholds have been reported in the literature (Lamonte and Ainsworth, 2001).

MET values established for a wide range of PA (Ainsworth *et al.*, 1993; Ainsworth *et al.*, 2000) and RMR values measured or estimated by predictive equations based on measures of person's age, height, and weight (Keim *et al.*, 2004) enable EE estimation by recording the type of PA undertaken and the time spent in the activity. This methodology of recording PA is used in observation, interview and self-report questionnaires and diaries. Despite of less accurate to measure EE, intensity and duration of PA than objective methods, such as double label water (DLW), indirect calorimetry and accelerometer, the self reports methods are inexpensive and more frequently used in large-scale health-related studies (Lamonte and Ainsworth, 2001).

The Bouchard physical activity record (B-PAR) (Bouchard *et al.*, 1983), one of the most commonly used diaries, involves self-reported PA intensity and duration recorded each 15 min throughout the day, and scored using categorical values from 1 to 9, according to PA. Each score corresponds to a median EE which is expressed as MET or as $kcal.kg^{-1}.15min^{-1}$. The B-PAR has been used as a reference method to evaluate PA questionnaires (Pols *et al.*, 1996; Pols *et al.*, 1997a; Pols *et al.*, 1997b; Chasan-Taber *et al.*, 2002). In the few validation studies of the B-PAR (Schulz *et al.*, 1989; Bratteby *et al.*, 1997; Fogelholm *et al.*, 1998), the daily EE was estimated by DLW. In addition, adolescents (Bratteby *et al.*, 1997) or women (Schulz *et al.*, 1989; Fogelholm *et al.*, 1998) were used as participants. Moreover, MET values for each score or number of scores were different to the ones originally proposed (Schulz *et al.*, 1989; Bratteby *et al.*, 1997; Fogelholm *et al.*, 1998).

The purpose of this study was to evaluate the accuracy of the B-PAR in estimating daily EE and in characterizing the PA patterns of free-living humans over several days. The B-PAR data were compared with RT3 accelerometer data. The ability to provide detailed, temporal information about PA over extended periods makes the accelerometer perhaps the most suitable instrument to evaluate subjective measurement methods (Matthews and Freedson, 1995; McMurray *et al.*, 1998; Kohl *et al.*, 2000). An additional objective was to verify if young men- (19-23 years of age) recorded the B-PAR adequately.

METHODS

Sample and study design: 11 male 19 – 23 year old Physical Education and Exercise and Sport Science students were recruited. Their descriptive characteristics are provided in table 1. During August and September of 2004, participants wore an RT3 accelerometer for 4 consecutive days while simultaneously completing B-PAR. Each participant read and signed an approved written consent form. Queensland University of Technology Human Research Ethics Committee approved the participant recruitment and the data collection procedures.

Bouchard physical activity record (B-PAR): A 4-day recording (two weekdays, Saturday and Sunday) was completed consisting with wearing the RT3. Participants were instructed to record the scores (1 – 9, corresponding to nine categories of PA intensity) for each 15-min period, throughout the day. The average EE for each category and their corresponding list of activities have been established by Bouchard *et al.* (1983). These categories were explained and illustrated in detail to each participant before they started to record.

Accelerometer: The triaxial accelerometer TriTrac-RT3™ (Stayhealthy, Inc., Monrovia, CA, http://www.stayhealthy.com) is a small (71 x 56 x 28 mm), lightweight (65.2g), battery-powered instrument. The sensor in the RT3 is an accelerometer sensitive along three orthogonal axes (x, y, and z), which represent vertical, anteroposterior, and mediolateral motion, respectively. The accelerometers used in the RT3 have a dynamic range of 0.05–2.00 *g*, are sensitive in the range 2–10 Hz, and are calibrated at 5.3 Hz (Powell et al. 2003). The acceleration is measured periodically, culminating in the vector magnitude of movement (calculated as VM = $(x^2 + y^2 + z^2)^{0.5}$) and stored in memory. The outputs from the accelerometer are EE ($kcal.min^{-1}$) and VM ($counts.min^{-1}$). The outputs were downloaded to a PC, using specific software. The algorithm used by the accelerometer to generate its outputs is unavailable to the researchers. Prior to the commencement of recording, participants' details including age, height, weight and gender were loaded and the RT3 set to record data each minute. The device is worn clipped to the waistband and the participants were instructed to remove the RT3 for sleeping, bathing and swimming activities and to detail times when the RT3 was removed.

Resting Metabolic Rate (**RMR**): was measured using a Deltatrac II metabolic cart (Datex-Ohmeda Corp., Helsinki, Finland http://www.datex-ohmeda.com), a continuous open-circuit indirect calorimetry device with ventilated canopy. Participants lay supine in a comfortable position, listening radio to prevent sleeping, whilst the transparent canopy was placed over the head for 30 minutes. The last 10 minutes of data were used for analyses. Expired gas was analysed for oxygen concentration via a paramagnetic O_2 sensor and for carbon dioxide concentration via an infrared absorption technique. Gas analysers were calibrated prior to each RMR measurement against standard mixed reference gases (5% CO_2, 95% O_2). The Deltatrac II metabolic cart was connected to an IBM-compatible personal computer for storage of data. The Weir equation (Weir, 1949) was used to convert O_2 and CO_2 values to RMR values (kcal.d^{-1}).

Data analysis: As the data from the B-PAR were reported in periods of 15 min, the data from the accelerometer recorded each minute summed for the same 15-min periods. For time periods when the participants reported they were awake and not wearing the accelerometer, the RT3 data were considered missing. These data were replaced by B-PAR data.

Three types of comparisons were undertaken to estimate the agreement between the measurements of B-PAR and RT3: a) considering each 15-min period individually; b) using daily EE averaged over 4 days; and c) using time engaged in PA.

For the first type of comparison, linear correlation and linear regression analysis were used. In this study, the accuracy represents how close the B-PAR estimation is to RT3 measurement and the precision refers to the inverse of the error variance. To compare the accuracy of B-PAR in relation to RT3, simple linear regression was used with the complete model: $Y = \beta_0 + \beta_1 X + \varepsilon$, where Y and X are the EE from B-PAR and RT3, respectively and ε, the error of the model. The hypothesis $\beta_0 = 0$ was evaluated using t test. If β_0 was not different from zero ($P > 0.05$), a new regression analysis was undertaken through the origin ($Y = X = 0$) according to model: $Y = \beta_1 X + \varepsilon$ (Neter *et al.*, 1996). The hypothesis $\beta_1 = 1$ was evaluated by t test. The estimated value of β_1, multiplied by 100, relates to the accuracy (%) of B-PAR and the r^2, the determination coefficient, relates to its precision allowing the accuracy to be represented by only one value (one parameter of the linear model). Therefore β_1 means the agreement between the measurements by two methods. For the simple linear correlation and simple linear regression analysis (Neter *et al.*, 1996), RT3 data were discarded when the participants were sleeping (B-PAR = 1), or were not wearing the device. Similarly, corresponding data from B-PAR for the same 15-min periods were deleted.

For each participant, 15-min periods were classified into three PA levels (PAL), according to the CDC-ACSM's (Center for Disease Control and Prevention of the American College of Sports Medicine) position statement (Pate *et al.*, 1995): a) light (EE < 3 MET), moderate (EE 3 - 6 MET) and high (EE 6 MET). For the RT3, the value of VM corresponding to 3 and 6 MET are 984 and 2340.8 counts, respectively (Rowlands *et al.*, 2004). The B-PAR scores 1 to 4, 5 to 7 and 8 to 9 correspond to light, moderate and high PA intensity, respectively (Bouchard *et al.*, 1983; Dionne *et al.*, 2000).

RESULTS

The EE was overestimated in 14.7% on average by B-PAR in relation to RT3 (Table 2). The agreement between B-PAR and RT3 EE measurements was low for all participants as estimated by simple linear regression (Table 3). Both participants showing the highest and the lowest precision (r^2) over- or under-estimated the EE too many 15-min periods when recording PA (Figure 1). It also happened to the others (raw data not showed). Despite of the differences between average daily EE (from 4 days) estimated by B-PAR and RT3 had been normally distributed, as 95% of differences lie between mean ± 1.96 SD, they were large at the individual level (Fig 2).

The participants' RMR assessed by Deltatrac differed from that estimated from RT3 (Table 2).

Due RT3 was not worn all time, from 292 to 1842 $kcal.d^{-1}$ were not recorded by RT3, according to B-PAR data (Table 2, Fig 3). The missed RT3 data were estimated from B-PAR to compare daily total EE.

Some participants, mainly participants 8, 9 and 10, were not wearing RT3 when engaged on moderate or intense PA (Fig 4). During 40% of time doing intense PA, the RT3 accelerometer was not worn (Table 4). The time engaged on moderate and intense PA was overestimated by B-PAR for the most of participants, in relation to RT3, considering only the time when the RT3 was worn (Table 5).

The participants chose well the B-PAR scores from 1 to 4 and 9 for their PA. However, the scores 5-8 did not have good correspondence with the RT3 VM outputs (Fig 5A). For each one of the nine B-PAR scores recorded by participants, the RT3 recorded a large range of VM values (Fig 5B). The right choice of the B-PAR score was not related to the participants' PA behaviour. Intensely active participants recorded well the B-PAR scores (Fig 5D) or not (Fig 5C), as well as sedentary participants recorded well (Fig 5F) or not (Fig 5E).

Considering data from each participant, the correlation between B-PAR scores and VM over the 4-days period, weekend days and two weekdays ranged from r = 0.12 to 0.8. For some participants there was a large difference between r for weekend and weekdays (Table 6).

In 192 (14.7%) 15-min periods during which participants recorded they were sleeping (B-PAR score = 1) and not wearing the RT3, recorded average VM output ranged from almost zero to more than 500 counts.min^{-1}. From these 192 periods, 22% appear to be due to errors of participants (8.3%) because he had drank alcohol as recorded in food intake record (data not showed) or error inherent to method (13.5%) corresponding to either the first or the last sleeping 15-min period. However, the remaining 78% (150) of the periods where the participants recorded as sleeping and the VM > 0, there is none reasonable explanation other than vibration, or incidental jostling of the RT3 (Cradock *et al.*, 2004). In 90% (135 periods) of 15-min periods where the participants recorded as sleeping, the VM > 0 and VM 10 counts.min^{-1}. Therefore, when VM 10 counts.min^{-1}, it was assumed that RT3 was not worn. Otherwise, when VM > 10, it was assumed that RT3 was worn, independently of the recorded B-PAR scores. When B-PAR score > 1 (participant was not sleeping) and the 15-min period average VM 10 counts.min^{-1}, it was assumed that RT3 was not worn and the RT3 data were considered missed. Based on a VM cut-off of 10 counts.min^{-1}, 138 15-min periods were eliminated from analysis (totalling 684 counts.min^{-1}, 0.07% of the total counts for 11 participants).

As in the current study the participants' RMR was evaluated, it was possible to estimate the participants' MET for each 15-min period, using RT3 EE output and to verify the correspondence of EE to the VM values proposed by Rowlands *et al.* (2004) of 984 counts.min^{-1} to 3 MET and of 2340.8 counts.min^{-1} to 6 MET. The VM values were plotted against MET values estimated by RT3 and 98.4% of the 15-min period recorded by RT3 were rightly classified in light, moderate and intense PA (Fig 6).

DISCUSSION

The data of the current study showed that there was EE overestimation of 14.7% by B-PAR in relation to RT3 accelerometer. Matthews & Freedson (1995) also found that B-PAR overestimated the daily EE in 14% compared to Tritrac R3D. Compared to indirect calorimetry, studies with the TriTrac-R3D have produced variable results: some has showed very high agreement (Eston *et al.*, 1998; Sherman *et al.*, 1998), others that accelerometer underestimated (Chen and Sun, 1997; Fehling *et al.*, 1999) or overestimated the EE (King *et al.*, 2004). Moreover, some studies had showed that TriTrac-R3D underestimated EE for some PA and overestimated for others (Bouten *et al.*, 1997; Jakicic *et al.*, 1999; Nichols *et al.*, 1999; Welk *et al.*, 2000; Campbell *et al.*, 2002; Rodriguez *et al.*, 2002). As the RT3 has been available in market recently, there are only a few published studies evaluating it (DeVoe *et al.*, 2003; Powell *et al.*, 2003; King *et al.*, 2004; Powell and Rowlands, 2004; Rowlands *et al.*, 2004). RT3 counts correlated significantly with O_2 uptake in children and adults (Powell *et al.*, 2003; Rowlands *et al.*, 2004). On the other hand, B-PAR is accurate to estimate EE at the individual level (Schulz *et al.*, 1989; Fogelholm *et al.*, 1998) as there was a EE underestimation of 8% compared to DLW in overweight women (Fogelholm *et al.*, 1998). Bratteby *et al.* (1997) found average difference less than 1% when estimating daily EE by DLW and B-PAR, although these authors had modified the MET values for some B-PAR scores. However, using B-PAR Lichtman *et al.* (1992) found that the obese participants (BMI > 27 $kg.m^{-2}$) over-reported EE expended in physical activities in 51% compared to DLW.

B-PAR overestimated EE compared to RT3 in the current study and some explanations may be considered. Firstly, the RMR assessed by Deltatrac and estimated by RT3 accelerometer differed. The RT3 recorded greater RMR, but smaller total EE, compared to B-PAR.

Secondly, to not wear RT3 accelerometer may explain EE underestimation by RT3 accelerometer. The participants of the current study wore the RT3 on average 12.8 $h.d^{-1}$, 76% of awaking time and one 12^{th} participant’s data was excluded because he did not wear the accelerometer as the expected. Leenders *et al.* (2001) found participants worn accelerometer 13.5 $h.d^{-1}$ (75-85% of awaking time). Cradock *et al.* (2004) found that middle-school students wore Tritrac R3D an average 12.5 $h.d^{-1}$ over 5 days. Due to lack of participant's compliance with wearing the accelerometer, Conn *et al.* (2000) found that only 28% of 36 participants generated Tritrac R3D data and Bouten *et al.* (1996) found difficulty to make the interpretation of findings. A minimum number of hours wearing the accelerometer of 8 (Cradock *et al.*, 2004) or 10 (Schmidt *et al.*, 2003) per day have been considered as a criteria for include the participants' data into study. Despite the time wearing RT3 accelerometer by the participants of the current study to be similar to those found in other studies, from 292 to 1842 kcal.d^{-1} were not recorded by RT3 accelerometer. It was possible to estimate the EE to those periods when RT3 was not worn because the participants filled in B-PAR simultaneously wearing RT3 accelerometer. Matthews & Freedson (1995) found Tritrac R3D underestimated the daily EE (average over 3 days) up to 954 kcal in relation to a PA record. The average difference was 360 kcal.d^{-1} (14%). Leenders *et al.* (2001) suggested that 100 to 150 kcal.d^{-1} may not have been recorded by R3D due to participants took off the RT3 for doing high intensity PA contributing to EE underestimation of 35% during free-living conditions over 7 days, compared with the DLW method.

To avoid damage the accelerometer mainly during moderate and intense PA may have contributed to take accelerometer off and to underestimate EE. In the current study, 37% of intense PA was not recorded by RT3. Some participants (1, 2 and 7) had all time of moderate and intense PA recorded by RT3 whereas others, the time not recorded by RT3 accelerometer ranged from 4.3 to 86.7%. To take off the accelerometer, mainly during PA of high intensity may contribute to EE underestimation. However, when RT3 was not worn, EE was estimated by B-PAR, and there was EE underestimation by B-PAR in relation of RT3 suggesting that other factors may have contributed to EE underestimation by accelerometer rather than to have taken off accelerometer. General criticisms of accelerometers include the inability to detect arm movements, locomotion on a grade (example: walking uphill), and external work performed by pushing, lifting, or carrying objects, because acceleration patterns remain essentially unchanged under these conditions, despite the increase in effort required, yielding underestimation of EE (Welk, 2002; King *et al.*, 2004). Other problems of measuring EE by accelerometer are: a) the variability inter monitors TriTrac-R3D (Jakicic *et al.*, 1999) and TriTrac-RT3 (Powell *et al.*, 2003; Powell and Rowlands, 2004); b) different number of counts recorded by the accelerometer for different PA expending similar energy (Swartz *et al.*, 2000); c) inadequate attachment of the monitor; and d) not detection of EE either during recovery from exercise or due the thermic effect of food (Sherman *et al.*, 1998). Anthropometric measures, such as leg length and height, have been suggested to affect accelerometer output (Rowlands *et al.*, 2004). However, in the current study, correction for height did not decrease the variability of the VM in relation to B-PAR scores (data not shown).

On the other hand, the limitations of B-PAR may also have contributed to EE overestimation in relation to RT3 accelerometer. In the current study, the activity performed by participant could not be on the list proposed by Bouchard *et al.* (1983) and the participant had to choose a score corresponding equivalent PA. There is a detailed compendium of PA (Ainsworth *et al.*, 1993; Ainsworth *et al.*, 2000), but its 12 pages detailing PA limit its use by participants throughout the day. The MET values proposed by Bouchard *et al.* (1983), based in median energy costs, differ from those proposed by Ainsworth *et al.* (2000). Some authors, such as Bratteby *et al.* (1997), Ekelund *et al.* (1999) and Pols *et al.* (1997a) have used the B-PAR with MET values which differ from those proposed by Bouchard *et al.* (1983). Other limitations of B-PAR include the possibility of different PA performed over 15-min period and inability of recording B-PAR throughout the day. When comparing accelerometer and B-PAR over small periods (15 min) throughout the day, it is important to set up the participants' watch with the RT3's watch. Otherwise a whole 15-min period recorded by RT3 will not be the same 15-min period recorded by B-PAR.

Another probable explanation of EE overestimation by B-PAR in relation to RT3 is the wrong choices of B-PAR scores by participants. Cumulative misinterpretation of category descriptions may have produced the EE overestimation by B-PAR in relation to RT3. For example, the participant 1 recorded 294 15-min periods of light intensity on B-PAR while the RT3 recorded 333. In addition, the participant recorded 7 periods of high intensity PA on B-PAR while the RT3 recorded 3 periods (Table 5).

All participant showed low accuracy and low precision ($r^2 < 0.6$) when recording PA compared to accelerometer. On simple linear regression analysis, EE, a common variable was used. On equation $Y = \beta_0 + \beta_1 X$, if $\beta_1 = 1$ and $\beta_0 = 0$, it means that accuracy of B-PAR data in relation to RT3 data is 100% (Table 3). High precision means low error variability. So, if one method is not accurate and it is precise, it could be possible to adjust the method and improve its accuracy. Sherman *et al.* (1997) and

Chen & Sun (2002) also used simple linear regression to compare EE measured by Tritrac-R3D and indirect calorimetry.

There was a low agreement between B-PAR and RT3 when comparing not only EE but also B-PAR scores and RT3 VM. Considering the average VM scores, participants recorded B-PAR scores 1 to 5 and 9 accurately, which followed a right gradient of body movement, but this was not the case for scores 6 - 8 (Fig 5A). Welk *et al.* (1998) also found an increase in VM with increasing scores but the gradient, as in the current study, was imperfect, when children 10 – 12 years old wore the Tritrac-R3D and their scores reported by trained research assistants. The disagreement between VM and B-PAR scores found in the current study may be partly due to incorrect scoring. Some inactive participants overestimated their PA intensity when recording B-PAR maybe due their small daily PA intensity spectrum. Some moderate PA may have been recorded as intense (high B-PAR score).

The agreement between EE estimated B-PAR and RT3 accelerometer was variable, ranging from small (r = 0.16) to good (r = 0.73) according to the participant (Table 6) suggesting that some participants had more compliance than others. The success in quantification of PA with accelerometer depends on participant compliance wearing the accelerometer during most of the waking hours (Bratteby *et al.*, 1997; Sherman *et al.*, 1998). Compliance can be assessed in either plotting VM output from each participant against time or scanning the accelerometer minute-by-minute outputs.

The interferences in recorded accelerometer VM caused by external vibrations under daily living conditions, for example when the individual wearing the device is in a car are typically lower in magnitude and of shorter duration and do not contribute much to the overall signal (Bouten *et al.*, 1997; Welk, 2002; 2004). In the current study, external vibrations may have contributed to VM > 0 counts.min^{-1} recorded by the RT3 in 14.7% of the time recorded by the participants as sleeping (B-PAR score = 1) since the VM was < 10 counts.min^{-1} in 90% of them. Therefore for VM above 10 counts.min^{-1}, it was considered RT3 was being worn. This threshold proposed herein is consistent with the value proposed by Cradock *et al.* (2004) using the Tritrac-R3D accelerometer. However, the use of threshold had minimal effect on the final result as 3.3% of the total of 4128 15-min periods (an average 48 min.d^{-1} for each participant) had VM < 10 counts.min^{-1} and less than 0.1% of the total counts were discarded because were error inherent to B-PAR method where the participants recorded as sleeping and the RT3 recorded VM > 10 counts.min^{-1}. More importantly, a close appraisal of the data enabled us to verify the use of the device by matching with the written records.

The number of output counts differ among different marks and models of accelerometers for the same PA (Hendelman *et al.*, 2000; King *et al.*, 2004; Rowlands *et al.*, 2004). The RT3 assess higher VM counts than RD3 during testing situations (DeVoe *et al.*, 2003). This difference in accelerometer output limits a comparison among studies using the different instruments. The conversion of VM to MET allows not only the comparison of different accelerometers but also the estimation of the time spent in sedentary, moderately active and active PA (Bouten *et al.*, 1996; Nichols *et al.*, 1999; Welk, 2002; Keim *et al.*, 2004; Rowlands *et al.*, 2004). In the current study, the RT3 accelerometer output EE divided by RMR assessed to each participant allowed us to calculate the MET for each 15-min period. Plotting these RT3 calculated MET against RT3 VM, 98.4% of the 15-min periods were rightly classified as light (< 3MET), moderately active (3 to 6 MET) or active (> 6MET) using VM cut-points values specific to RT3 triaxial accelerometer defined by Rowlands *et al.* (2004) (Fig 6).

In conclusion, the EE was overestimated by B-PAR in relation to RT3 not only due to accelerometer and PA records limitations but also mainly due to the lack of participants' commitment. The validity of the recording the B-PAR score is dependent on the active participation of the subject being investigated. The participants took off the accelerometer in about 40% of the time for doing intense PA. Recording PA mainly when accelerometer is not worn allows to estimate EE and time doing PA more accurately. As long as there is no single ideal, inexpensive and simple method for the assessment of energy expenditure and physical activity, the combination of two methods as physical activity records and accelerometer may be used to estimate the volume intensity of daily PA and EE in order to determine the optimal dose of PA to modify disease risk.

Table 1 - Descriptive characteristics of the 11 young male participants

Variable	Mean ± standard deviation	Minimum - maximum
Age (years)	21.2 ± 1.3	19 - 23
Height (cm)	175 ± 4.8	167 – 181
Weight (kg)	72 ± 10.4	54.7 – 85.5
BMI (kg/m^2)	23.45 ± 2.68	19.1 – 27.6

Table 2 – Body Weight (BW), resting metabolic rate (RMR), daily energy expenditure (EE) and daily time sleeping and wearing RT3 accelerometer over 4 days from 11 young male participants

Participant	BW (kg)	RMR (kcal)		EE (kcal.) [1]		Time (h)	
		Deltatrac	RT3	B-PAR[2]	RT3	Sleeping[3]	Wearing RT3[4]
1	76.3	1886	2059	3436	2870	9.5	12.2 (84%) [5]
2	73.4	1843	2016	3449	3313	6.9	14.3 (84%)
3	74	1829	1987	3676	3271	7.9	12.4 (77%)
4	61.7	1670	1757	3257	2624	7.9	12.2 (76%)
5	55.8	1814	1699	3082	2635	8.4	11.7 (75%)
6	54.7	1714	1656	3642	2917	8.1	14.1 (89%)
7	78.5	2074	2088	4040	3503	7.4	14.6 (88%)
8	83.7	2232	2131	4710	4151	7.9	9.9 (61%)
9 [6]	85.5	1800	2174	3593	3860	7.5	10.7 (65%)
10	72.2	1901	1958	3912	3123	9.1	12.4 (83%)
11	76.5	1771	2002	3291	2936	8.1	12.8 (80%)
Mean	72.0	1867	1957	3644	3200	8.1	12.3 (77%)

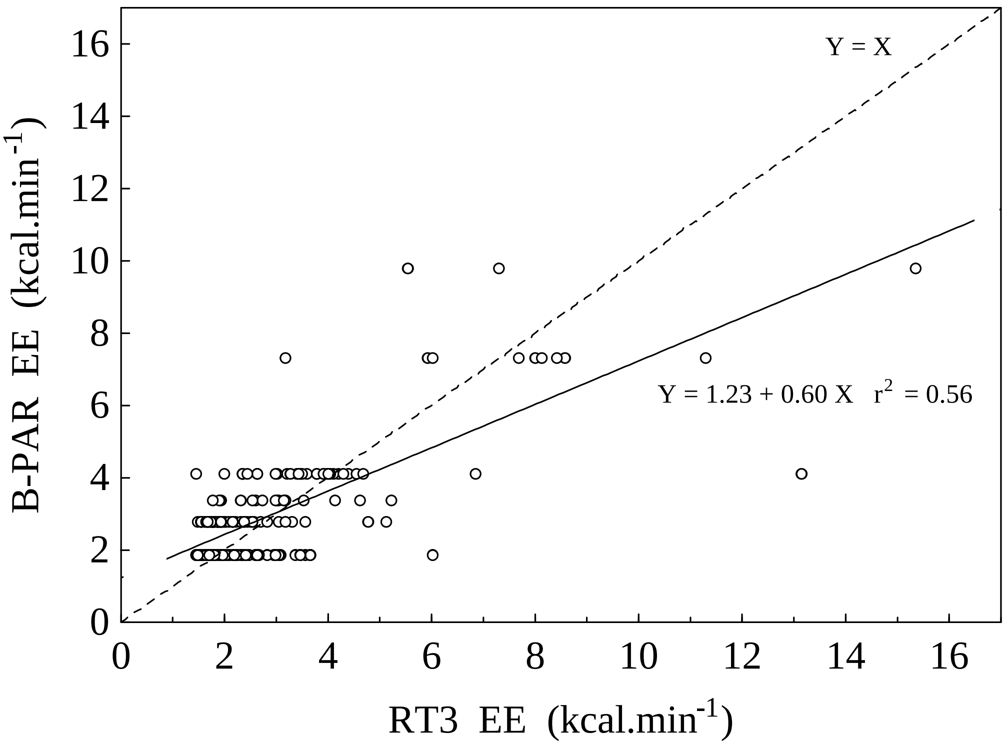
[1] EE was estimated from B-PAR data, when accelerometer was not worn,
[2] B-PAR = Bouchard physical activity record.
[3] According to Bouchard physical activity record.
[4] Vector magnitude > 10 counts.min^{-1}.
[5] Percentage of time wearing RT3 in relation to the awake time.
[6] Data from 3 days.

Table 3 - Comparison between energy expenditure estimate by Bouchard physical activity record (B-PAR) and accelerometer RT3 over 4 days period from 11 young male participants

Participant	Equation [a]	r^2	N [b]
1	Y = 1.71** + 0.66**X	0.34	193
2	Y = 1.30** + 0.62**X	0.56	209
3	Y = 2.48** + 0.32**X	0.17	199
4	Y = 2.34** + 0.26**X	0.08	195
5	Y = 1.49** + 0.57**X	0.20	183
6	Y = 1.89** + 0.60**X	0.55	214
7	Y = 1.09** + 0.84**X	0.55	231
8	Y = 2.56** + 0.46**X	0.14	153
9	Y = 1.45** + 0.35**X	0.24	119
10	Y = 2.71** + 0.28**X	0.02	190
11	Y = 0.94** + 0.84**X	0.50	201

[a] Y is B-PAR and X is RT3. Hypothesis: $\beta_0 = 0$ and $\beta_1 = 1$ (** $P < 0.01$).
[b] N = number of 15 min-periods that accelerometer was worn.

A



B

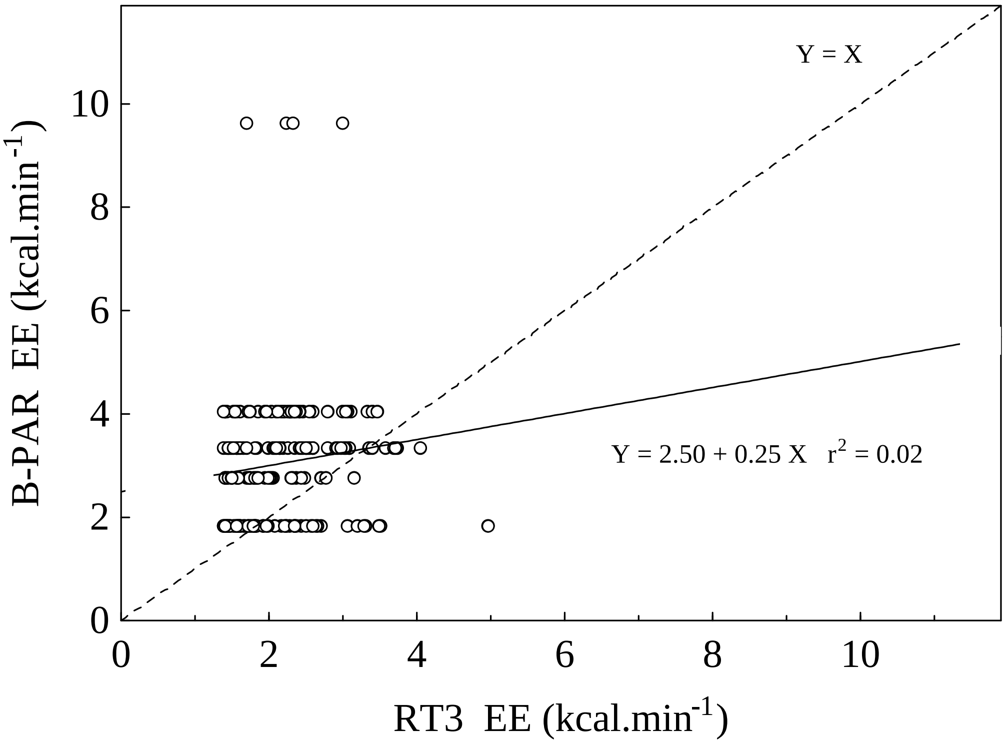


Figure 1 – Comparison between energy expenditure (EE) estimations by Bouchard physical activity record (B-PAR) and RT3 accelerometer (RT3) over 4 days period. A. from participant 2. B. from participant 10 (Y is B-PAR and X is RT3 data).

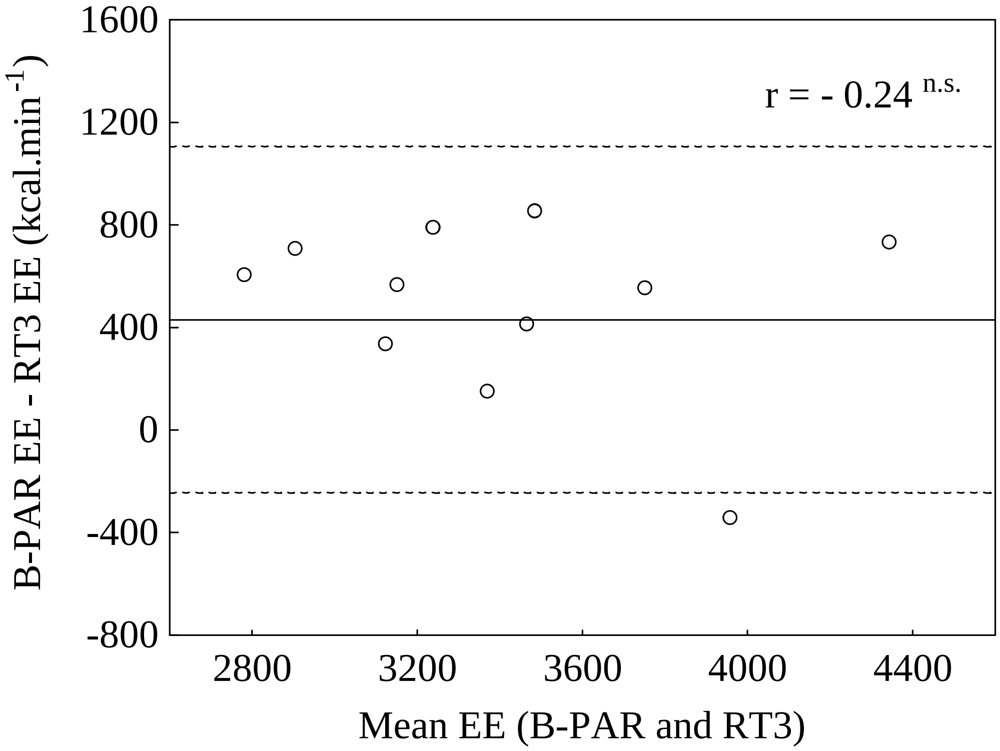


Figure 2 – Bland and Altman (1986). Difference on energy expenditure (EE) of 11 participants estimated by Bouchard physical activity records (B-PAR) and by RT3 accelerometer over 4 days against the mean of estimation by both methods. The *lines* represent the mean difference (*solid*) and mean ± sd (*dashed*). $^{n.s.}$ $P > 0.05$.

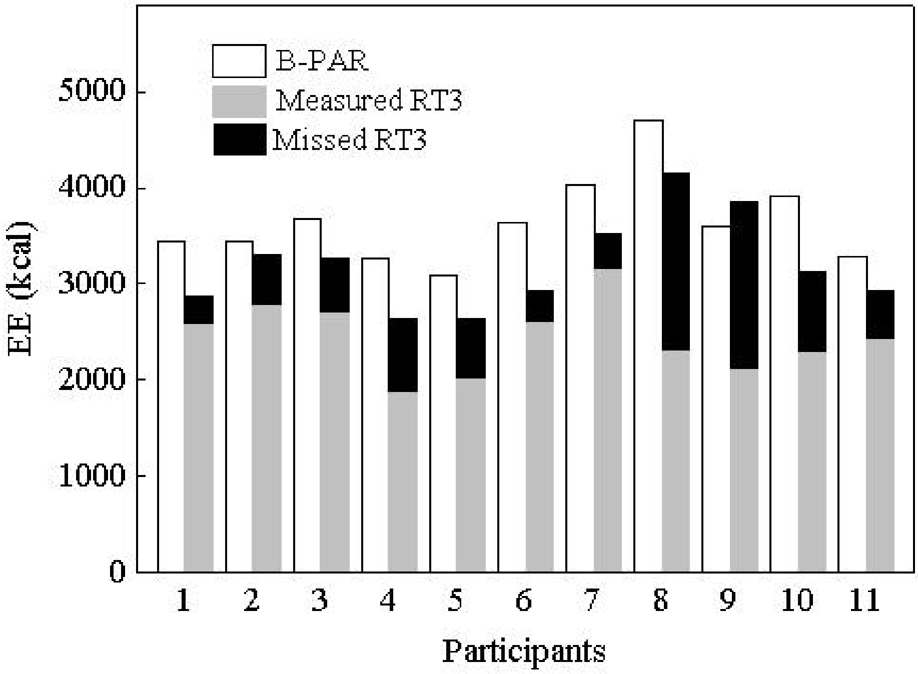


Figure 3 - Energy expenditure (EE) (average of 4 days) estimated by Bouchard Physical Activity (B-PAR) and recorded or missed by RT3 (but recorded by B-PAR).

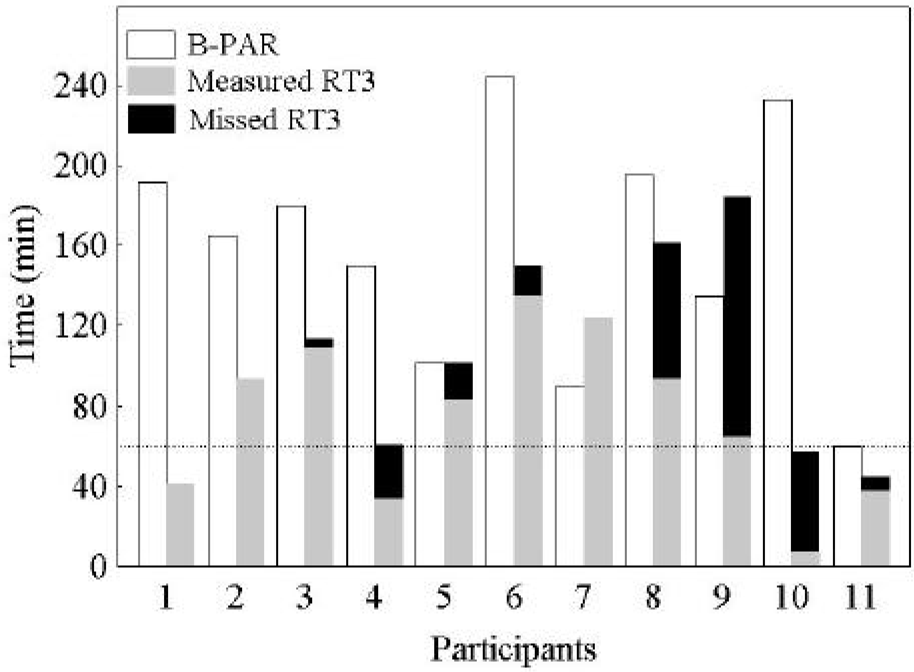


Figure 4 – Time (average of 4 days) engaged on moderate and intense physical activity (>3MET) by the participants as recorded by B-PAR, recorded by RT3 and or missed (but estimated by B-PAR, when RT3 was not worn). The dash line is the daily 60 minutes of moderate-intensity physical activity recommended to adults to promote a healthful body weight as well as health and vigour (IMFNB 2005).

Table 4 – Time (min, average from 4 days) spent in light, moderate, and high physical activity according to Bouchard Physical Activity Record (B-PAR) and RT3 accelerometer by 11 young male participants

Physical activity	B-PAR[2]	RT3	
		Recorded[2]	Estimated[3]
Light (< 3MET[1])	1281.5	1050.9	230.6
Moderate (3 MET < 6)	110	93.3	10.2
Intense (6MET)	48.5	30.6	17.8

[1] Metabolic equivalent = EE / RMR.
[2] Included sleeping time.
[3] Time not recorded by accelerometer (not worn) and estimated from B-PAR.

Table 5 – Number of 15 min-periods[1] spent in light (< 3MET[2]) moderate (3 to 6 MET) and high (6MET) PA intensity according to Bouchard Physical Activity Record (B-PAR) and RT3 accelerometer over each day

Participant	PA	Day 1		Day 2		Day 3		Day 4		Total	
		B-PAR	RT3	B-PAR	RT3	B-PAR	RT3	B-PAR	RT3	B-PAR	RT3
1	Light	75	80	78	79	84	88	57	87	294	334
	Moderate	7	6	3	2	4	0	30	0	44	8
	Intense	5	1	2	2	0	0	0	0	7	3
2	Light	87	85	79	78	55	77	57	57	278	297
	Moderate	2	8	1	1	29	9	0	0	32	18
	Intense	4	0	1	2	7	5	0	0	12	7
3	Light	80	77	74	76	51	75	71	66	276	294
	Moderate	0	3	2	3	42	18	0	5	44	29
	Intense	0	0	3	0	0	0	0	0	3	0
4	Light	37	36	85	86	59	69	75	89	256	280
	Moderate	2	3	3	2	12	2	16	2	33	9
	Intense	0	0	0	0	0	0	0	0	0	0
5	Light	81	78	82	79	71	76	61	62	295	295
	Moderate	5	8	4	7	2	2	2	1	13	18
	Intense	1	1	0	0	8	3	0	0	9	4
6	Light	88	87	61	78	78	82	58	63	285	310
	Moderate	3	4	24	6	6	3	9	9	42	22
	Intense	0	0	2	3	3	2	14	9	19	14
7	Light	83	82	83	82	83	79	76	73	325	316
	Moderate	0	1	4	5	0	12	0	13	4	31
	Intense	0	0	0	0	9	1	11	1	20	2
8	Light	21	20	71	69	50	58	83	85	225	232
	Moderate	0	1	13	15	15	7	4	2	32	25
	Intense	0	0	0	0	0	0	0	0	0	0
9	Light	46	43	68	68	71	64	---	---	185	175
	Moderate	0	3	1	2	0	7	---	---	1	12
	Intense	0	0	2	1	0	0	---	---	2	1
10	Light	80	91	55	82	80	85	69	73	284	331
	Moderate	12	1	28	1	5	0	0	0	45	2
	Intense	0	0	0	0	0	0	4	0	4	0
11	Light	94	94	69	69	72	74	81	83	316	320
	Moderate	0	0	0	0	0	8	1	2	1	10
	Intense	0	0	0	0	10	0	3	0	13	0

[1] when accelerometer was worn.

[2] MET: metabolic equivalents = EE / RMR.

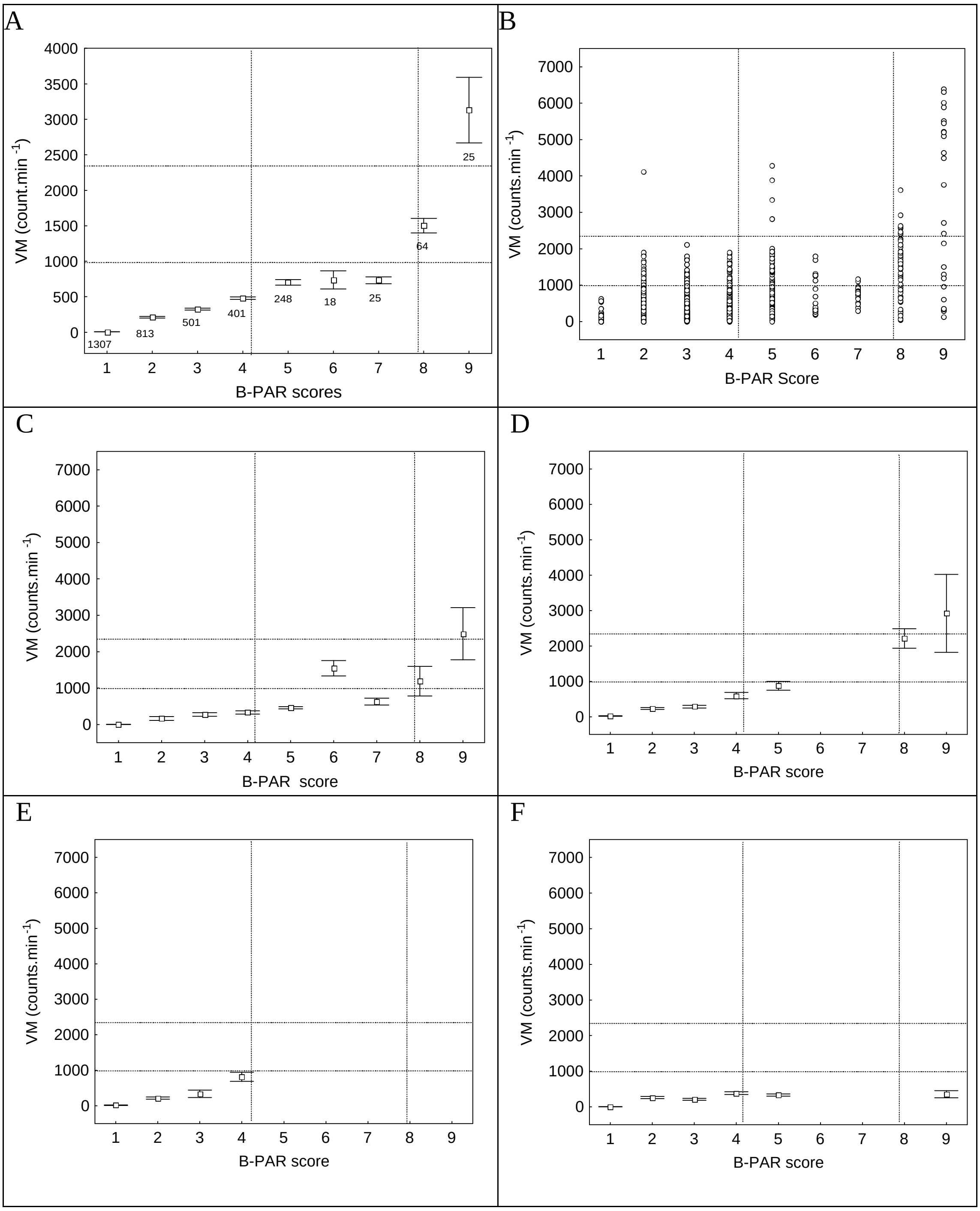


Figure 5 – Vector Magnitude (VM) from RT3 accelerometer in relation to B-PAR scores. A. Mean ± standard error. Below each mean is the number of 15-min period, recorded by 11 participants over 4 days. B. Amplitude of VM values of each score recorded. C-F. Mean ± standard error from participants 1, 2, 9 and 10, respectively. The dash lines, which represent 3 and 6 METs, are the threshold of light, moderate and intense PA level, being the horizontal in relation to VM according to Rowlands *et al.* (2004) and the vertical in relation to B-PAR.

Table 6 – Pearson's linear correlation coefficient (r), between RT3 accelerometer output (vector magnitude) and Bouchard physical activity record (scores) from each 11 young male participant over total time (4 days), weekend days and two weekdays

Participant	Total		Weekend		Weekdays	
	r [1]	N [2]	r	N	r	N
1	0.55	193	0.72	101	0.56	92
2	0.73	212	0.81	94	0.71	118
3	0.46	199	0.47	102	0.42	97
4	0.28	195	0.12	108	0.46	87
5	0.47	183	0.51	97	0.43	86
6	0.70	218	0.78	103	0.55	115
7	0.73	231	0.75	127	0.45	104
8	0.45	153	0.52	90	0.28	63
9	0.56	119	0.51	80	0.81	39
10	0.16	190	0.15	109	0.14	81
11	0.69	201	0.61	97	0.61	104

[1] Hypothesis: = 0 was not verified because the data sets have not bivariate normal distribution.

[2] N = number of 15 min periods when accelerometer was worn.

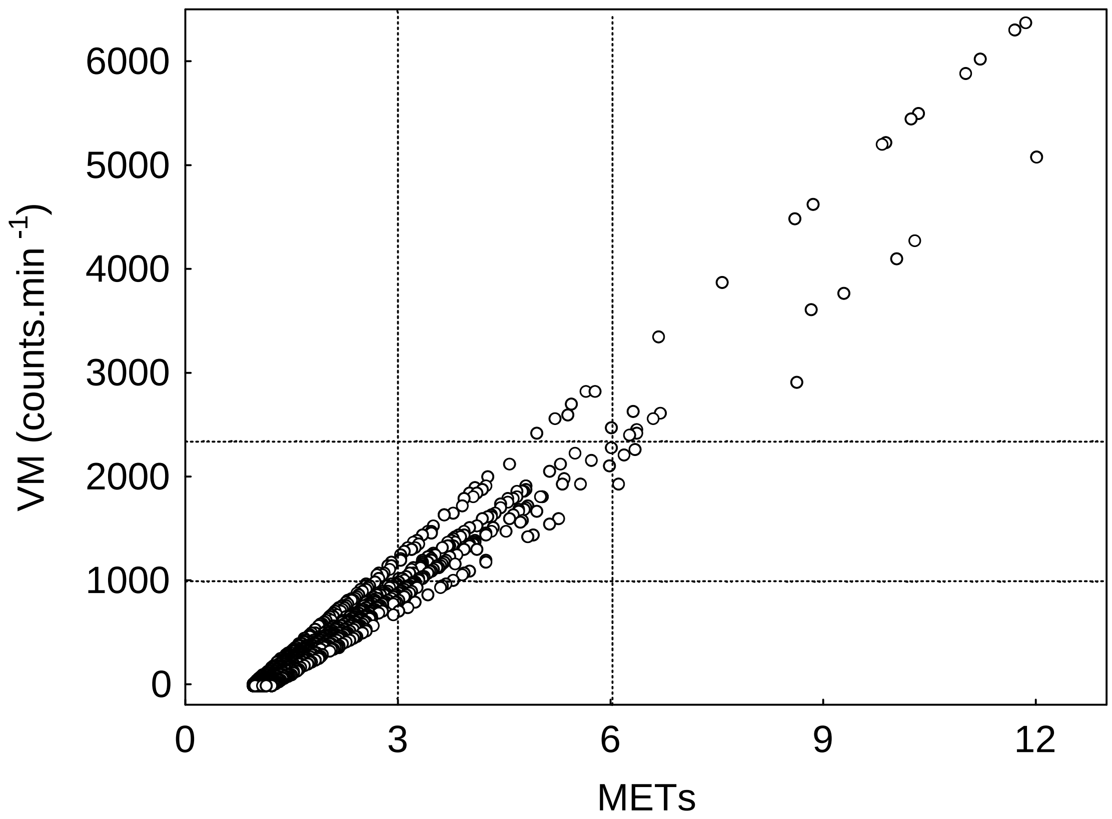


Figure 6 – Vector Magnitude (VM) from accelerometer RT3 recorded by 11 participants over 4 days in relation to their METs values, which were estimated using RT3 EE output and RMR measurements by Deltatrac. Each dot represents a 15-min period. The dash lines are the threshold of light, moderate and intense PA level, being the horizontal in relation to VM (according to Rowlands *et al.* (2004) and the vertical in relation to Pate *et al.* (1995).

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CHAPTER 2

EVALUATION OF VALIDITY OF DIETARY INTAKE REPORTS OF YOUNG MEN USING SELF-REPORT FOOD RECORDS AND DIETARY RECALL INTERVIEW

INTRODUCTION

Accurate measurements of food intake are important to studies of the association between diet and health (Briefel *et al.*, 1997; Lafay *et al.*, 1997). Food intake quantification should be a complete and accurate record of all food consumed on specified days, and where the choice of food and drink consumed has not been influenced by the act of recording (Livingstone *et al.*, 2003). Food intake can be quantified by many methods which can be classified in three categories: observed food records, interview and self-report.

In the observed food records, an observer watches the participant and records the type and amount of the food eaten. The amount of the food can be previously weighed or estimated visually by the observer. The observations, which may occur conditions in controlled feeding trials in metabolic wards (Hise *et al.*, 2002) or in free-living conditions (Jain *et al.*, 1980; Eck *et al.*, 1989), may be done by a trained observer or by someone from the participant's family, such as wife (Jain *et al.*, 1980) or parents (Eck *et al.*, 1989). Although the participant may change his habitual food intake when he knows he is being watched (Hise *et al.*, 2002), it is possible to observe participants without them knowing (Eck *et al.*, 1989).

In the interview method, a researcher asks the participants about their consumption of foods for certain previous periods, usually from one to seven days. In the 24-hour dietary recall method (24hDR), often used in large surveys due its short administration time, the participant tells the interviewer the quantity of foods and beverages consumed in the preceding day. This method has a relatively small participant burden, participants’ food intake pattern is unchanged and the collected data are more reliable due to the personal contact with the interviewer. However, the participants’ recall depends on memory.

In the self-report method, the participants record all food and beverages consumed during a period of time, usually ranging from 1 to 7 days. The amount of consumed food can be estimated visually or previously weighed. A disadvantage of recording is that the habitual intake may be influenced by the recording process (Biro *et al.*, 2002; Hoidrup *et al.*, 2002).

Methods where the amount of food consumed is weighed previously are the most accurate. However, their use is time consuming, requires a high level of cooperation, is cumbersome for free-living participants and may influence the participants’ food intake. The estimation of the amount of food is rapid, has low cost, has high cooperation rates and is less demanding for participants than weighing of food (Edington *et al.*, 1989; Kortzinger *et al.*, 1997). However, the accuracy of estimating food is highly variable among participants according to their skills, memory and commitment to the study. Previous training also improves the food portion estimates (Howat *et al.*, 1994).

It is now recognized that some participants invalidate food reports by self-reports or interviews, frequently under-estimating the food intake (Black, 2000a). The most common source of errors of participants when reporting food intake are: low accuracy for visual estimation of the amount of food, participants’ poor memory, changing the habitual food intake, conscious and unconscious failure to report. If there is under or over-reporting of food intake, serious issues for the interpretation of epidemiological studies about diet and health variables are raised. This could be even more serious if the under or over reporting related to the consumption of selected foods or in specific participants for example, a higher degree in obese than in lean participants) (Johnson *et al.*, 1994; Beaton *et al.*, 1997; Johansson *et al.*, 1998; Lissner, 2002). Therefore, it is always necessary to check the accuracy of the reported food intake of each participant in each study. A key problem is how to identify those individuals who have provided data of poor validity. As macro- and micronutrients must be provided within the quantity of food needed to fulfil the energy requirement, the EI is a substitute measurement of the food intake. If EI is underestimated, then the intakes of macro- and micronutrients are also likely to be underestimated (Livingstone and Black, 2003).

Over decades, the “validity” of food intake methods has been evaluated by comparing one method with another, but not knowing which method, if any, was valid. Since the 1980s, with the advent of biomarkers of food intake and energy expenditure (EE), such as urinary nitrogen excretion and doubly labelled water measures, it has been possible to determine that under-estimation of food intake is very common when the information is derived from self-reported dietary assessments (Black, 2000b). The reported EI can be validated resting on that daily EI must equal daily EE, when body stores are stable and on that over a few days, changes in body stores can be ignored (Black, 2000a). Good agreement between EI and EE has been demonstrated when the weight is stable (Black *et al.*, 1993).

When EI < EE, the EI reported may be not representative of habitual intake. For one to be more confident that reported EI is a plausible measure of the actual diet during the measurement period, 95% confidence limits of agreement between reported EI and EE have been estimated for each reported EI. Using 95% confidence limits of agreement between reported EI and EE criteria, which is considered the standard method for validation of reported EI by Black (2000b), who found 34% of under-reports (UR) and 4% of over-reports, when 429 participants were evaluated from 22 studies, whose EE was assessed by doubly-labeled water. Using the same criteria, Sjoberg *et al.* (2003) found 26% of UR by Swedish adolescents and Samuel-Hodge *et al.* (2004) found 81% of UR by women with type 2 diabetes. According to Black (2000b), the lowest number of UR, 18 and 28%, was found in elderly (> 75 years) and young adults (18-29 years), respectively. However, his dataset includes only three studies with participants' aged between 18-25 years, in Mexico, UK and North Ireland, with 30 participants in total, from both genders. When EE is unknown, the identification of EI UR can be based on the Goldberg cut-offs methods (Goldberg *et al.*, 1991; Black, 2000a; Black, 2000b), in which reported EI is expressed as EI / BMR and compared with expected PAL (Physical Activity Level) for that population.

The aims of the present study were: to assess UR in obese and non-obese youth men in Brisbane, Australia; to evaluate the accuracy of the Goldberg cut-off method for identifying UR and to compare two methods of EI assessment.

METHODS

Participants: Thirty four healthy young men (94% of participants university being students), whose characteristics are shown on Table 1, were recruited from the local community in the city of Brisbane, Australia. Each participant read and signed an approved written consent form. Queensland University of Technology Human Research Ethics Committee approved the participant recruitment and the data collection procedures.

Dietary assessment: Two methods were used: a) The 24-hour dietary recall (24hDR) individual were conducted by a dietician and were compried of four steps. Firstly, the interviewee was asked to recall a list of foods consumed in the previous day (not the previous 24 h). In the second step, the interviewer probed for details about each of the foods and fluids listed. On the third step, the participant saw 48 slides about food size on a computer screen. On the fourth step the participant had an opportunity to correct and / or complete any inaccurate or forgotten data in his previous recall. b) The 4-day food record (4dFR): After completing the 24hDR, the participants were given food intake recording sheets and instructions on how to complete them throughout a day. Measurement was undertaken during the same 4 days during which they completed the physical activity record. The period of recording included two week days, a Saturday and Sunday.

The 24hDR and 4dFR data were entered into the Foodworks© (v. 3.02) nutrient analysis software (Xyris software Pty Ltd., Brisbane, Australia, http://www.xyris.com.au). Dietary records were checked and details regarding recipes and portion sizes were noted and clarified with each participant. As this study was part of a bigger study, there was another individual meeting with the participant, 1 to 2 weeks after the first interview. Therefore, when necessary, details about their 24hDR and 4dFR could be clarified. Macronutrients were expressed as absolute intake as well as source of energy (percentage of daily EI).

The mean standard error (se) for EI was calculated for each participant, according to Balogh *et al.* (1971).

$$se = CV_{wEI} / d^{1/2}$$

where CV_{wEI} is the within-participant variation in EI and d is the number of days of dietary assessment. The minimum d required for determine the mean EI of individual participants with a se of ± 10% is:

$$d = CV_{wEI}^2 / se^2$$

Resting metabolic rate (**RMR**): Due to challenges in measuring the basal metabolic rate (BMR), RMR was assessed by a continuous open-circuit indirect calorimetry device. Respiratory gases were collected continuously for 30 minutes but only the data from the last 10 minutes were used for analyses. Participants lay supine in a comfortable position, listening to a radio to prevent sleeping whilst monitored to ensure that they remained awake. Data collection took place in a thermal-regulated environment with minimal light and noise. Participants fasted for 5 hours, were involved in minimal physical activity prior to arrival and rested lying for 30 min in the lab before the measurement. A Deltatrac II metabolic cart (Datex-Ohmeda Corp., Helsinki, Finland http://www.datex-ohmeda.com) was used to assess RMR of half of the participants. Expired gas was analyzed for oxygen concentration via a paramagnetic O_2 sensor and for carbon dioxide concentration via an infrared absorption technique. Due to technical problems, the Moxus O_2 system (AEI Technologies, Pennsylvania, USA) was used to assess the RMR of the remaining participants. Participants were fitted with a Hans-Rudolf headset (with two-way breathing valve and pneumotach) and a nose clip. Both gas analyzers were calibrated prior to each measurement against standard mixed reference gases. The Weir equation (Weir, 1949) was used to convert O_2 and CO_2 values to RMR values.

$$RMR = [(1.106\ CO_2 + 3.941*O_2] \times 1440\ min.d^{-1}$$

Where, RMR is the resting metabolic rate ($kcal.d^{-1}$), CO_2 is the carbonic dioxide production rate ($L.min^{-1}$) and O_2 is the oxygen consumption rate ($L.min^{-1}$).

Body composition: Percentage body fat was measured by dual-energy X-ray absorptiometry (DEXA, DPX-Plus; Lunar Corporation, Madison, WI). The participant removed any materials that could attenuate the x-ray beam, such as jewellery, watches, clothes with zippers and shoes and laid on his back in the centre of the table. Participants remained motionless in the supine position while the scanning arm of the DEXA passed over their body from head to toe in parallel 1-cm strips. DEXA measurements were made using a constant potential x-ray source of 76 kVp and a cerium filter that produces dual-energy peaks of 38 and 62 keV. The soft tissue mass (fat and lean tissue) is measured pixel-by-pixel as a beam of photons penetrates the participant's body. When the two beam energies pass through the body they attain a certain degree of attenuation depending on the mass and type of tissue. The ratio of the mass attenuation coefficients of soft tissue varies linearly with the fatty fraction, which is calculated from measurements in all pixels containing only soft tissue (Svendsen *et al.*, 1993). Normal scan mode takes approximately 27 minutes. Quality assurance was assessed by analysing a phantom spine provided by the manufacturer, and daily calibrations were performed before scans using a calibration block provided by the manufacturer. Using the DPX-L adult software, version 1.33 (Lunar Corporation) it was possible to calculate the body fat mass. Participants were considered obese if the body fat was 20.0%.

Daily energy expenditure: A 4-day physical activity record (B-PAR) (Bouchard *et al.*, 1983) was completed simultaneously with recording food intake. Participants were instructed to record the scores (1-9, corresponding to nine categories of PA intensity) for each 15-min period, throughout the day. These categories and their corresponding list of activities, as established by Bouchard *et al.* (1983), were explained and illustrated in detail to each participant before they started to record.

EE was calculated for each 15-min period, multiplying individual participant's RMR by the MET (metabolic equivalent, which is a multiple of BMR) associated to each score. The B-PAR scores 1, 2, 3, 4, 5, 6, 7, 8 and 9 correspond to 1, 1.5, 2.3, 2.8, 3.3, 4.8, 5.6, 6 and 7.8 METs, respectively (Bouchard *et al.*, 1983).

Evaluation of the validity of energy intake reports: The validity of food records was determined by two methods:

Method 1: direct comparison of EI and EE: The validation of reported EI rests on EI = EE + changes in body stores and the assumption that at the changes in body stores can be ignored over a period of few days, and therefore daily EI = daily EE.

The 95% confidence limits of agreement between EI and EE were calculated, according to Black (2000b) and Black and Cole (2001) (Black, 2000b; Black and Cole, 2001)as

$$CL\,(EI)_{0.95} = EE * [\pm 2\,(CV_{wEI}{}^{2} / d + CV_{wEE}{}^{2})^{1/2}] =$$

where CV_{wEI} is the within-participant variation in EI, d is the number of days of diet assessment and CV_{wEE} is the within –participant variation in EE.

Averages values for CV_{wEI} and CV_{wEE} were calculated according to Black *et al.* (2000a).

$$\text{Pooled mean } CV_w = (\quad CV_i^2 / n)^{1/2}$$

where CV_i is the CV (CV_{wEI} or CV_{wEE}) calculated for each participant from the number of days of dietary assessment or EE assessment available for that participant, and n is the number of participants.

The pooled mean CVs for all participants, from 4dFR data, found in this study, $CV_{wEI} = 0.23$ and $CV_{wEE} = 0.15$, are the same ones as those suggested by (Black, 2000a).

For EI assessed by 4dFR,

$$C.L. (EI)_{0.95} = EE * (1 \pm 0.38)$$

$$0.62 \quad EI / EE \quad 1.38$$

Acceptable reports (AR) were defined as having the ratio EI / EE in the range 0.62 – 1.38, UR as EI / EE < 0.62, and over-reports as EI / EE > 1.38.

For EI assessed by 24hDR,

$$C.L. (EI)_{0.95} = EE * (1 \pm 0.55)$$

$$0.45 \quad EI / EE \quad 1.55$$

Method 2: Goldberg cut-off to identify diet reports of poor validity (Goldberg *et al.*, 1991; Black, 2000a). This method is supposed to be used when EE is unknown. In the current study, Goldberg method was used to evaluate its accuracy when compared to the method 1. To determine whether a value of EI / BMR is acceptable, the following must be satisfied:

$$PAL \times \exp[sd_{min} \times S / n^{1/2}] < EI / BMR < PAL \times \exp[sd_{max} \times S / n^{1/2}]$$

where PAL is the average physical activity level for the understudy population, sd_{min} and sd_{max} are -2 and 2 for the lower and upper 95% confidence limit, respectively, n is the number of participants (at individual level, n = 1), and EI / BMR is the individual ratio for each participants in the study or the average ratio for a group of participants. S is the overall coefficient variance for EI, BMR and energy requirements, and it is given by

$$S = (CV_{wEI}^2 / d + CV_{tP}^{\ 2} + CV_{wB}^{\ 2})^{1/2}$$

Where CV_{wEI} is the within-participant variation in energy intake, d is the number of days of diet assessment, CV_{wB} is the coefficient of variation of BMR measurements, and CV_{tP} is the total variation in PAL.

The values used for each factor were CV_{wEI} = 0.23, CV_{tP} = 0.15 (both were calculated from the dataset of the current study), and CV_{wB} = 0.04, according to Black (2000a). Therefore, S = 0.1932 for 4dFR and 0.2775 for 24hDR. PAL value used to calculate the Goldberg cut-offs was 1.85 as suggested for men aged 18 to 29 y (Black *et al.*, 1996). Acceptable reporters were defined as having the ratio EI / RMR, according to the method of dietary assessment at individual and group level (Table 2). The sensitivity of this method for detecting UR was calculated as the proportion of UR correctly identified. The specificity was calculated as the proportion of non-UR correctly identified as such (Black, 2000b).

RESULTS

As there were no significant differences of EI, RMR, EE and PAL between obese and non-obese (Table 3), the estimation of linear correlation among these variables and the comparison between the two methods of dietary intake was undertaken simultaneously for all participants, whatever their body fat. The 24hDR and 4dFR provided similar estimates of average daily energy and macronutrient intake expressed as energy source (Table 4). However, there were large variations between 4dFR and 24hDR estimates at the individual level. Despite the differences had been normally distributed (Gaussian), because 95% of differences fell between mean ± 1.96 sd, they were too large at individual level (Figure 1).

The within-participant day to day variation in EI (CV_{wEI}) of individuals was large (Figure 2A). When considering mean daily EI from two or three days, the variation decreases with the increasing the number of days of dietary assessment (Figure 2B and 2C). From 4dFR data, the se of EI was 11.5% at the group level. For 17 participants (50%), the individual mean EI was estimated with se 10%. The numbers of days of food recording required to determine the mean EI of individual participants of the current study with a se of ± 10% for 50, 70 and 90% of participants are 4, 7 and 13 days, respectively.

Considering the data from 4dFR, for the majority of the participants, the reported daily EI was smaller than the reported daily EE (Figure 3A) and there was no linear correlation between mean daily EI and the mean daily PAL (Figure 3B), the body fat (Figure 3 C) or RMR (Figure 3D).

A smaller number of UR was identified when EI was assessed by 24hDR than by 4dFR using either direct comparison (Figure 4A and 4C) or Goldberg method (Figure 4B and 4D). The direct comparison of EI and EE found three (8.8%) and seven (20.6%) URs when EI was estimated by 24hDR and by 4dFR, respectively (Figure 4A and 4C). The number of obese and non-obese UR identified was almost the same when EI was assessed by 4dFR (Figure 4C). When the EE is unknown, Goldberg cut-off may be used to identify UR. Despite the daily EE is known in this study, it was simulated one situation where EE is unknown to verify the accuracy of Goldberg cut-off to identify UR in relation to direct comparison of EI and EE, which is considered as the standard method by Black (2000b). When EI was assessed by 24hDR, three UR identified by direct comparison of EI and EE (the standard method), were correctly identified by Goldberg cut-off, but three AR were wrongly identified as UR (Figure 4B). When EI was assessed by 4dFR, Goldberg cut-off found six out seven UR identified by direct comparison of EI and EE (the standard method), but wrongly identified two AR as UR (Figure 4B). The sensitivity and specificity of Goldberg cut-off method were 0.86 and 0.93 respectively for 4dFR data, whereas 1.00 and 0.90 for 24dDR data, respectively.

At a group level, by both methods of dietary assessment, obese and non-obese groups provided UR, because their average EI / RMR (Table 3) were smaller than the Goldberg cut-off lower limit for groups (Table 2).

Using 4dFR data, there were significant differences between UR and AR in daily EI and macronutrients intake expressed in absolute values (Table 5) but no in relative values (Table 6). UR and AR did not differ each other in relation to intake of the most of vitamins and minerals (Table 7).

DISCUSSION

There was good agreement between the measurements of energy and macronutrients intake by 24hDR and 4dFR at the group level, as the average differences estimated by two methods was low (Figure 1 and Table 4). However, at an individual level, there was no good agreement between the measurements of individual intake of energy and macronutrients by 24hDR and 4dFR (Figure 1).

One possible explanation for the difference at the individual level between 24hDR and 4dFR could be the individual characteristics (Black and Cole, 2001). If a subject is an UR on one occasion, it is very likely that he/she will an UR on other occasions. In the current study, 33% of UR of EI assessed by 24hDR underreported EI assessed by 4dFR. High percentage of UR on more than one occasion has been identified when EI is assessed by the same (Briefel *et al.*, 1997; McKenzie *et al.*, 2002) or by different methods (Kortzinger *et al.*, 1997). When 24h DR was used to assessed EI, 55% of male under-reporters on the first occasion also under-reported on the second occasion, 1 month after (Briefel *et al.*, 1997). Among 50 participants, 34% underreported by both diet history and 7d FR methods (Kortzinger *et al.*, 1997).

Another individual characteristics that have been observed to account for reported EI is the body composition. More EI underreporting has been found in obese than in non-obese men (Mertz *et al.*, 1991; Heitmann and Lissner, 1995; Briefel *et al.*, 1997; Johansson *et al.*, 1998; Harrison *et al.*, 2000; Brunner *et al.*, 2001; Johansson *et al.*, 2001; Hoidrup *et al.*, 2002; Samuel-Hodge *et al.*, 2004) and adolescents (Bandini *et al.*, 1990). Andersson et al. (1996) found EI of 2500 ± 900 kcal and 2900 ± 400 kcal in obese and non-obese men aged 18 to 30 y, respectively when EI was assessed by 12 telephone recalls over a 3 month period. Analysing data from 840 men aged 20 to 29 y, Briefel *et al.* (1997) found EI / RMR of 1.83, 1.67 and 1.41 in men with BMI < 20.7 $kg.m^{-2}$, BMI ranging from $20.7kg.m^{-2}$ to 27.8 $kg.m^{-2}$ and BMI > 27.8 $kg.m^{-2}$, respectively. In the current study, when EI was assessed by 4dFR, obese had lower EI / RMR (1.37) than non-obese (1.51) although this difference has not been significant (Table 3). In the current study, there was no relationship between EI and body fat percentage (Figure 3C) and there was not difference between EI in obese and non-obese men when EI was assessed by either 24hDR or 4dFR (Table 3). Johnson *et al.* (1994) did not observed increased EI underreporting as fat mass and body fat percentage increased in men.

In the current study, EI had no relationship with RMR (Figure 3D) or PAL (Figure 3B). However, Goris and Westerterp (1999) found that RMR and PA were independently related to EI assessed by 7-day weighed FR in 24 lean women. RMR and PA explained 27% each one of variation in EI.

Another possible explanation for differences at the individual level between 24hDR and 4dFR may be different measurement contexts and skills required in recording and reporting. The 24hDR relies on memory and "bad" dietary intake is less likely to be reported to an interviewer than on a self-report (Hebert *et al.*, 2002; Hoidrup *et al.*, 2002). On the other hand, 4dFR may be more difficult to participants to complete than is the 24hDR. There is conscious and unconscious bias in the self-reporting food intake. The first includes lack of knowledge of the composition of mixed dishes, forgotten meals and wrongly estimate portion sizes; the latter includes failure to record food eaten in order to misrepresent a lower energy intake or a "healthy" diet; failure to record because it is time consuming and inconvenient; alteration in habitual intake due to conscious dieting or avoidance of snacks, in order to simplify records (Black *et al.*, 1993; Macdiarmid and Blundell, 1997; Poppitt *et al.*, 1998; Harrison *et al.*, 2000; Asbeck *et al.*, 2002; Biro *et al.*, 2002; Hebert *et al.*, 2002). Macdiarmid and Blundell (1997) found during an interview, after the participants had weighed and recorded all consumed food and drink over 7 days, 46% of participants admitted to have altered their diet consciously due to feeling embarrassed about recording specific food, due to much effort on weighing and recording or due to unavoidable circumstances.

One important question is if 24hDR and 4dFR are accurate for measuring habitual food intake, which differs of actual intake. Actual intake is food intake of one or few days. Habitual intake of an individual is the person's intake over a prolonged period of time (weeks or months rather than days). For energy, it is the intake that maintains weight stability. For other nutrients, it may be thought of as the intake required for producing a steady physiological state and hence to influence nutritional status and health in both the short and the long terms (Livingstone and Black, 2003). The individual energy requirement has been expressed as PAL, which is a multiple of BMR and enables the comparison among different person. From analysis of 574 measurements of EE assessed by double label water from people aged 2 to 95 years, Black *et al.* (1996) concluded that for a sustainable lifestyles, the PAL ranges from 1.2 to 2.5 and a mean PAL associated with men 18-29 years is 1.85, which agreed with the PAL estimated in the current study for obese, but not for non-obese (Table 3). The lower and upper limits of mean PAL of actual energy requirements are 1.22, for non-ambulant, and 4.7, for cyclists in Tour de France (Black *et al.*, 1996).

The 24hDR is accurate for measuring actual food intake at the group level but not at the individual level. Conway *et al.* (2004) measured the actual food intake of 42 men at a human study facility observing them during one day and found that the 24hDR undertook in the following day accurately estimated intakes of the energy, protein, carbohydrate, and fat in population of men, regardless of their BMI. The mean differences between recalled and actual consumption for the macronutrients and EI ranged from 8.0 to 9.3 %. However there was a significant variation in the ability of the men to recall food intake. The individual errors ranged from almost zero to around 30% (from -456 to 1311 $kcal.d^{-1}$) for EI. Karvetti and Knuts (1985), using similar methodology, found EI overestimation of 3% at the group level, however, about 45% of participants under- or over-estimated the EI by more than 20%. Jonnalagadda *et al.* (2000) found EI underestimation of 12% assessed by 24hDR (333 kcal), in average compared to EI required to maintain body weight. However, the errors ranged from up to around 50% (-1750 to 650 kcal), indicating poor agreement at the individual level. Poppitt *et al.* (1998) compared measured intake in a metabolic facility with self-report of food intake in the following day and found an mean EI underestimation of 13% by self-report of food intake. The individual errors ranged from almost zero up to 60%. Therefore 24-hour dietary recall and one-day self-report food record are accurate for measuring actual food intake at the group level but not at the individual level.

For the measurement of habitual intake, 24hDR is not accurate at an individual level due to large within-participant day-to-day variation in EI (CV_{wEI}). Over a 7-day period, the day-to-day variation was more than 2500 $kcal.d^{-1}$ in one participant independent of the day of week or of being, or not being, educated in dietetics and familiar with foods (Champagne *et al.*, 2002). Individual daily EI differed of the annual average up to about 7 MJ (1670 kcal) (Black, 2000a) and the CV_{wEI} ranged from 10 to 50%, with a pooled mean of 26% (Black *et al.*, 1986). From other 14 studies reviewed by Bingham (1987) and Nelson *et al.* (1989), CV_{wEI} ranged from 14 to 45%, with a pooled mean of 23%. In the present study, for the 4dFR data, CV_{wEI} ranged from 3.5 to 52.4%, with a pooled mean of 23.6%. The daily EI variability decreases with the increasing of days reporting food intake as observed not only in the current study (Figure 2) but also in others (Acheson *et al.*, 1980; McGee *et al.*, 1982; Black, 2000a). Analyzing EI data from 329 men, McGee *et al.* (1982) observed that a variability of daily EI using 3d FR was almost equivalent to those using 7d FR. According to Bingham (1987) the number of days required to determine the mean EI of individual participants with a se of ± 10% for 50, 70 and 90% of population is 5, 7 and 13 days, respectively. These values are similar to those found in the current study. Nelson *et al.* (1989) found that four days recording food intake ranked male participants with 90% of accuracy. Therefore, the 4dFR method was adequate for estimating habitual intake with se of ±10% for 50% of the participants in the current study. If, measuring EI over more days may decrease the variability, on the other hand, the accuracy may decrease due to participants' fatigue as suggested by some authors (McGee *et al.*, 1982; Livingstone *et al.*, 1990; Livingstone *et al.*, 1992; Goris and Westerterp, 1999; Biro *et al.*, 2002) and observed by Livingstone *et al.* (1990) during an interview, when the participants emphasized that to record the weight of items of food and fluid consumed over 7 days had interfered with their normal eating behaviour and that they had had difficulty in maintaining motivation after 4 days. Therefore, for the measurement of habitual intake, 4dFR is accurate at individual level.

At the group level, the number of days assessing food records needed for an accurate estimation of habitual intake depends on inter-participant variation. It is possible to improve the accuracy of assessing habitual intake at the group level increasing the number of participants or increasing the number of days assessing food records (Bingham, 1987; Volatier *et al.*, 2002). A greater number of days are necessary to assess accurately habitual intake of some nutrients that have more inter-participant variability (Bingham, 1987; Mennen *et al.*, 2002). In the current study, the average se of EI of 11.5% indicated that the FR data over 4 days were adequate for estimating habitual intake, at the group level.

The assumption of that participants are in energy balance (EI = EE) enable to verify the validity of their food intake records, and to identify UR using different strategies: EI < EE (Johnson *et al.*, 1994; Hoidrup *et al.*, 2002), EI < EE - 100 kcal (Mertz *et al.*, 1991) and EI < 0.8 EE (Kortzinger *et al.*, 1997; Asbeck *et al.*, 2002). The 95% confidence interval for EI / EE has been considered the standard method to identify UR (Black and Cole, 2001) because it takes into account number of days of diet assessment, daily variation in EI and EE. In the current study, 20.6% of participants underreported their EI by 4dFR. Using this criteria, Black (2000b) found 27.9% of male UR when analysing data from 21 studies, where EE was measured by DLW and EI was measured by records or questionnaires. Sjoberg *et al.* (2003) found 18% and 7% UR between girls and boys aged 15 to 17 y, respectively and Lingstone *et al.* (2003) found 14.3% of UR among 14 adults with mean age of 31.1 y by the 95% confidence interval for EI / EE criteria.

In the current study, due to the smaller ranging of age (18 to 25 y) of participants, it was possible to chose a more representative PAL value (1.85) for the population and therefore the sensitivity and specificity of Goldberg cut-off were higher than that found by Black *et al.* (2000b). The 4dFR enabled the Goldberg cut-off method to identify more UR than 24hDR as the individual cut-off interval is wider than that defined by 4dFR (Table 2).

The UR not only at the individual level but also at the group level, in the current study as well in many others arise serious issues for the interpretation of epidemiological studies about diet and health variables. The issues are even more serious when the underreporting is of specific foods resulting in underreporting of specific nutrients. Lower fat and carbohydrate intake of as well as higher protein intake were observed in UR than in non-UR (Rosell *et al.*, 2003; Subar *et al.*, 2003).

In the current study, the energy and macronutrient intakes were similarly underreported (Table 5) suggesting that there was not underreporting of specific foods and that the larger problem of underreporting may have been the underestimation of quantity of consumed food. Howat *et al.* (1994) observed a mean error of estimation of food portions of 40% in participants that had a training with photos of food portion size and of 47% in those who did not have the training.

The absence of difference significant in macronutrients intake expressed in energy percentage (Table 6) and in micronutrients (Table 7) between UR and AR found in the current study suggest that the diet data can be used in analysis with other variables in the evaluation of the relation between diet and health, since macronutrients are expressed in energy values. Other ways for analysing data have been proposed when underreporting is identified (Stallone *et al.*, 1997; Brunner *et al.*, 2001; McKenzie *et al.*, 2002; Linseisen *et al.*, 2003; Livingstone and Black, 2003; Rosell *et al.*, 2003; Subar *et al.*, 2003).

In conclusion, there were good agreement between the measurements of energy and macronutrients intake by 24hDR and 4dFR at the group level, but not at the individual level. The habitual intake can be accurately assessed by 4dFR. At the group level, obese and non-obese groups underreported EI by both 4dFR and 24hDR methods. At the individual level, 20.6% and 8.8% of participants underreported their EI by 4dFR and 24hDR, respectively considering the 95% confidence interval for EI / EE criteria. The sensitivity and specificity of Goldberg cut-off method were 0.86 and 0.93, respectively for 4dFR. For 24hDR, the corresponding values were 1.00 and 0.90, respectively. Repeated measures of dietary intake improve the precision, but not the validity of habitual intake measurements because not eliminate bias if there is participant-specific bias. In the evaluation of the relation between diet and health it is important to detect the degree and the distribution of misreported food intake.

Table 1 – Characteristics of 34 young men participant of the study.

Characteristics	Non – obese[1] (n = 20)[2]	Obese[1] (n = 14)[2]
Age (y)	21.3 ± 1.7 (19.2 – 25.6) [3]	22.4 ± 2.7 (18.0 – 25.8)
Body weight (kg)	71.1 ± 10.4 (54.5 – 87.8)	86.8 ± 12.3 (63.3 – 103.8)
Height (m)	1.75 ± 0.07 (1.60 – 1.89)	1.79 ± 0.06 (1.64 – 1.87)
BMI[4] ($kg.m^{-2}$)	23.2 ± 2.8 (18.8 – 28.8)	27.2 ± 3.2 (22.8 – 33.2)
Body fat (%)	13.4 ± 4.0 (6.0 – 19.3)	24.9 ± 4.92 (20.3 – 37.4)

[1] Non-obese has body fat < 20% and obese has body fat 20%.
[2] Number of participants.
[3] Mean ± sd (minimum – maximum).
[4] Body mass index.

Table 2 - Goldberg cut-offs for energy intake (EI) resting metabolic rate (RMR) at individual and group level for 34 young men according to the dietary method

Level	Dietary method[1]	
	24hDR	4dFR
Individual	1.06 < EI / RMR < 3.22	1.26 < EI / RMR < 2.72
All participants (n = 34) [2]	1.68 < EI / RMR < 2.03	1.73 < EI / RMR < 1.98
Obese [3] (n = 14)	1.59 < EI / RMR < 2.15	1.67 < EI / RMR < 2.05
Non-obese [3] (n = 20)	1.63 < EI / RMR < 2.09	1.70 < EI / RMR < 2.02

[1] 24hDR = 24 hour dietary record; 4dFR = 4 day food record.
[2] Number of participants.
[3] Obese has body fat 20% and non-obese has body fat < 20%.

Table 3 – Body fat, daily energy intake (EI), resting metabolic rate (RMR), daily energy expenditure (EE) and physical activity level (PAL) of obese and non-obese young men

Characteristics	**Non-obese** [1] **(n = 20)** [2]	**Obese** [1] **(n = 14)**
Body fat (%)	13.4 ± 4.0 (6.0 – 19.3) [3]	24.9 ± 4.9 (20.3 – 37.4)
EI 24hDR [4]	2645 ± 700 (1440 - 4011)	2892 ± 661 (1720 - 3999) [n.s.]
EI 4dFR [5]	2720 ± 537 (1903 - 3750)	2736 ± 529 (1781 - 3548) [n.s.]
RMR	1846 ± 282 (1349 - 2283)	1988 ± 271 (1502 - 2584) [n.s.]
EE	3597 ± 644 (2533 - 4796)	3668 ± 590 (2744 – 4773) [n.s.]
PAL (= EE / RMR)	1.95 ± 0.16 (1.59 – 2.26)	1.85 ± 0.20 (1.50 – 2.26) [n.s.]
EI 24hDR / RMR	1.45 ± 0.40 (0.91 – 2.18)	1.48 ± 0.36 (0.82 – 2.03) [n.s.]
EI 4dFR / RMR	1.51 ± 0.38 (0.88 – 2.22)	1.37 ± 0.17 (0.98 – 1.65) [n.s.]
EI 24hDR / EE	0.75 ± 0.23 (0.43 - 1.16)	0.81 ± 0.24 (0.42 1.20) [n.s.]
EI 4dFR / EE	0.78 ± 0.19 (0.46 – 1.20)	0.75 ± 0.13 (0.51 – 0.97) [n.s.]

[1] Non-obese has body fat < 20% and obese has body fat 20%.
[2] Number of participants.
[3] Mean ± sd (minimum – maximum).
[4] 24hDR = 24-hour dietary record.
[5] 4dFR = 4-day food record.
[n.s.] P > 0.05 for the comparison between groups using a two-tailed Student t-test for group means.

Table 4 – Daily macronutrients and energy intake (EI) evaluated by 24-hour dietary recall (24hDR) and 4-day food record (4dFR) from 34 young men

Dietary intake	Dietary method	
	24hDR	**4dFR**
Proteins (g)	121.6 ± 42.3 (51.9 – 225.0) [1]	113.3 ± 28.5 (60.7 – 178.5)
Fat (g)	96.3 ± 31.4 (32.2 – 152.5)	96.1 ± 20.2 (60.6 – 132.5)
Carbohydrates (g)	335.8 ± 102.3 (142.4 – 591.4)	318.7 ± 80.4 (180.9 – 545.2)
EI Total (kcal)	2747 ± 686 (1440 – 4011)	2726 ± 526 (1781 – 3750)
EI from proteins (%) [2]	19.0 ± 4.6 (12.8 – 30.3)	18.0 ± 3.8 (12.3 – 28.8)
EI from fat (%) [2]	31.4 ± 6.5 (18.3 – 44.1)	32.0 ± 5.1 (18.5 – 40.6)
EI from carbohydrates (%) [2]	49.1 ± 9.3 (35.0 – 68.4)	46.7 ± 7.0 (32.8 – 61.5)

[1] Mean ± sd (minimum – maximum).
[2] Energy source = 100 x nutrient intake (g) x nutrient energy value / EI. The nutrient energy value for protein, fat and carbohydrate are 4, 9 and 4 kcal.g^{-1}, respectively.

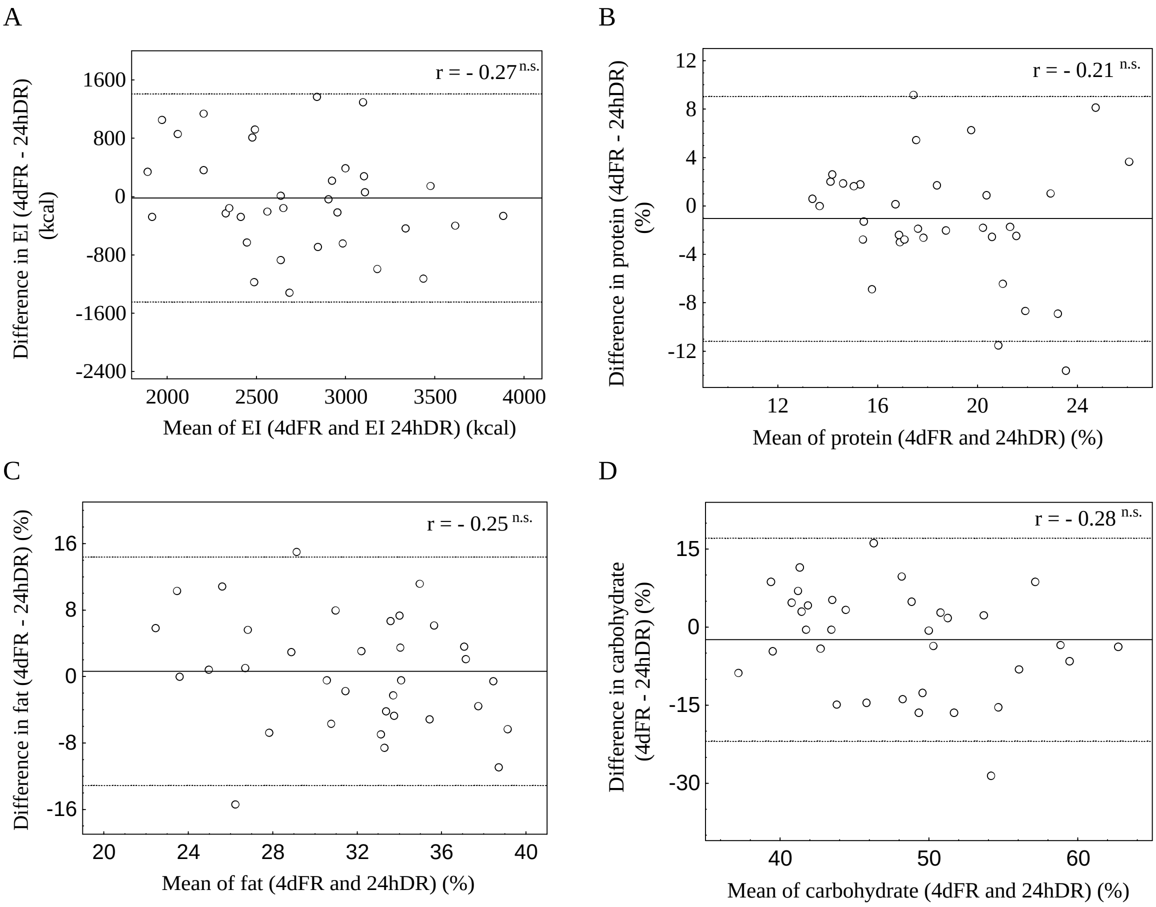

Figure 1 – Bland and Altman (1986) plot. Differences in daily energy intake (EI) (A) protein (B), fat (C), and carbohydrate intake (D) of 34 young men, estimated by 4-day food records (4dFR) and 24-hour dietary recall (24hDR) against the mean of the estimations by both methods. The *lines* represent the mean difference (*solid*) ± 1.96 sd (*dashed*). $^{n.s}$ $P > 0.05$.

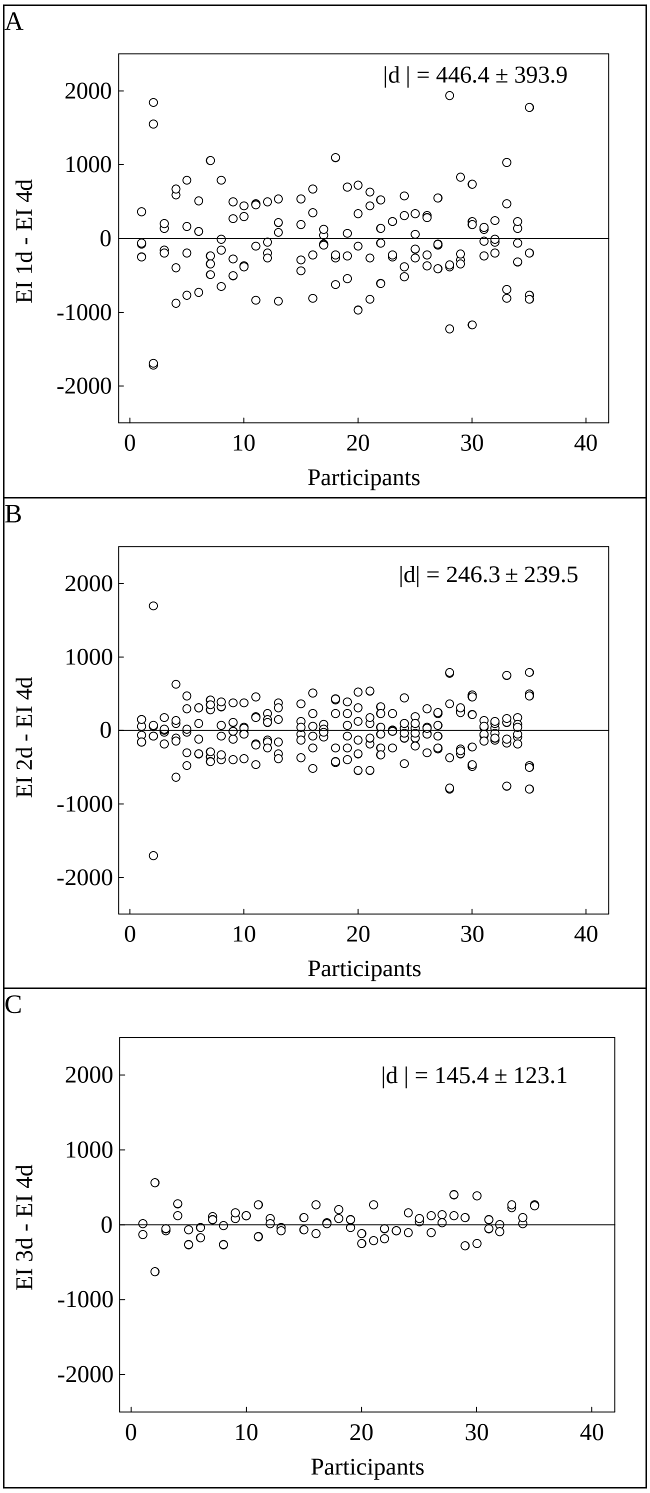

Figure 2 - Individual energy intake (EI) variation of 34 youth men assessed by 4-day food record: differences between four days average EI (EI 4d) and daily EI (EI 1d) (A), average two days EI (EI 2d) (B) and average three days EI (EI 3d) (C). d is the absolute difference (mean ± sd).

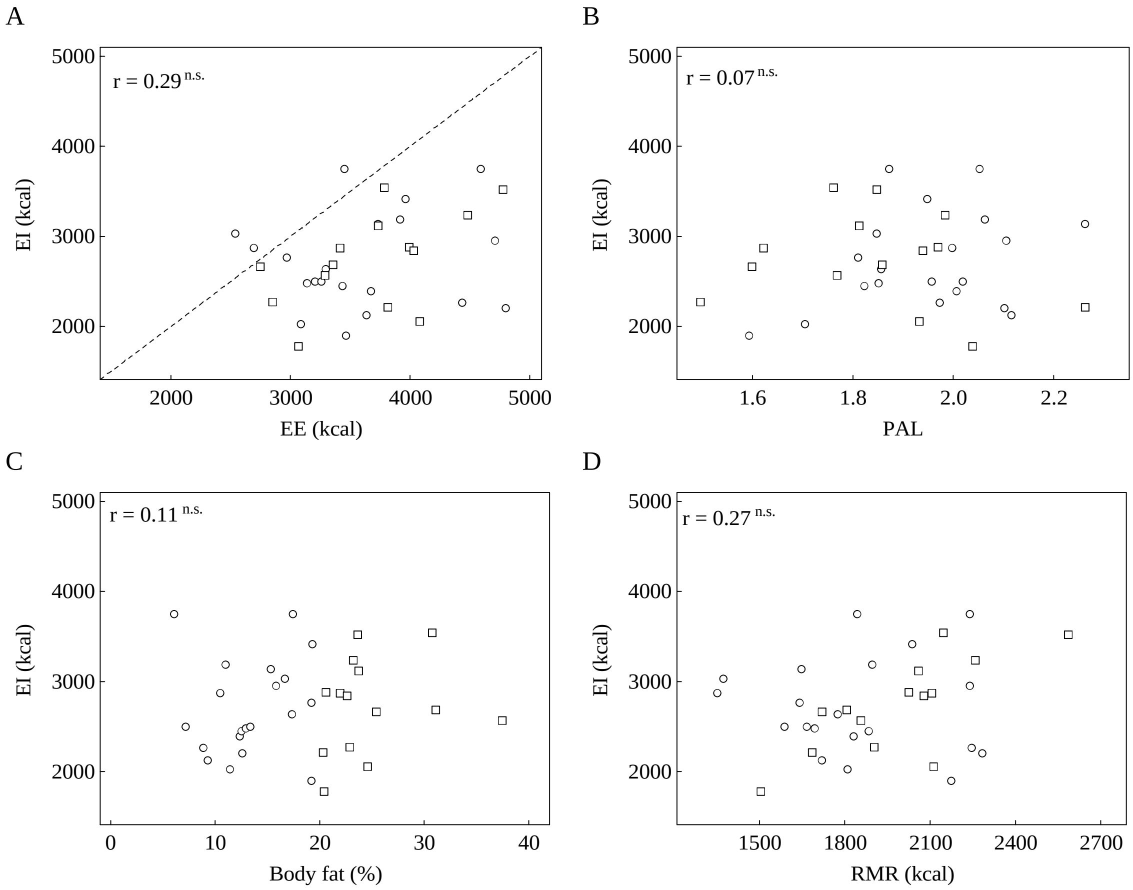

Figure 3. Average daily energy intake (EI) assessed by 4-day food record plotted against average daily energy expenditure (EE) from physical activity diaries (A), physical activity level (PAL) (B), body fat (C) and resting metabolic rate (RMR) (D). = obese; = non-obese. The linear coefficients of correlation (r) were estimated from all 34 young men data. [n.s] $P > 0.05$.

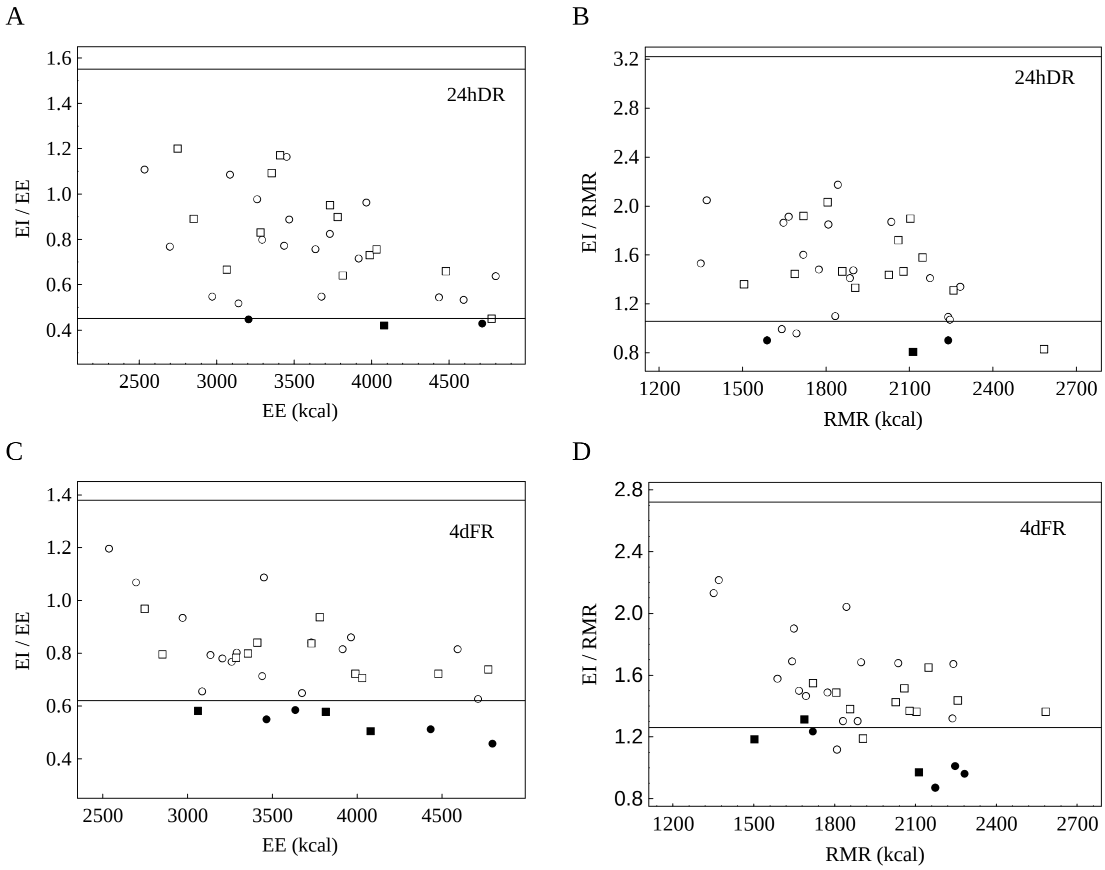

Figure 4 – Energy Intake (EI) / Energy Expenditure (EE) against EE (A, C) and EI / Resting Metabolic Ratio (RMR) against RMR (B, D) in 34 youth men. EI was assessed by 24-hour dietary recall (24hDR) (A, B) or by 4-day food record (4dFR) (C, D). The lines represent the 95% of confidence limits of EI / EE (A, C) or the Goldberg cut-offs (B, D). and = under-reporters: EI / EE < 0,45 (A) or EI / EE < 0.62 (C). and = obese; and = non-obese.

Table 5 - Daily energy and nutrient intake of 34 young men that provided under- and acceptable self-report by 4-day food record

Dietary intake	**Under-reports[1] (n = 7)[2]**	**Acceptable reports (n = 27)**
Energy Intake (kcal)	2080 ± 179 (1781 – 2270)[3]	2894 ± 449 (2025 – 3750) *
Protein (g)	88.9 ± 19.8 (60.6 – 115.7)	119.6 ± 27.1 (77.9 – 178.5) **
Total Fat (g)	75.2 ± 14.1 (60.6 – 92.4)	101.5 ± 17.9 (72.6 – 132.5) **
Saturated (g)	27.2 ± 7.0 (18.3 – 37.7)	41.8 ± 10.37 (19.4 - 59.2) **
Polyunsaturated (g)	12.2 ± 1.5 (10.9 – 14.9)	13.5 ± 3.3 (7.2 - 21.7) n.s.
Monounsaturated (g)	29.2 ± 6.2 (22.0 - 37.4)	37.4 ± 7.0 (25.2 – 49.3) **
Cholesterol (mg)	239.3 ± 150.0 (72.0 - 468.1)	379.0 ± 130.6 (189.0 – 636.0) *
Carbohydrate (g)	245.0 ± 55.7 (180.9 - 316.1)	337.8 ± 75.2 (218.6 - 545.2) **
Sugars (g)	116.9 ± 23.0 (85.2 - 155.4)	159.2 ± 68.5 (27.3 - 310.5) *
Starch (g)	126.7 ± 48.3 (67.8 - 212.7)	176.9 ± 52.1 (58.8 - 267.6) *
Alcohol (g)	4.25 ± 6.7 (0.0 - 17.1)	16.6 ± 23.7 (0.0 - 77.4) *
Fiber (g)	24.2 ± 6.5 (12.2 - 32.2)	26.6 ± 9.3 (12.7 - 51.7) n.s.

[1] Under-reports (EI / EE < 0.62) and acceptable reports (0.62 EI / EE 1.38).
[2] Number of participants.
[3] Mean ± sd (minimum – maximum).
n.s. P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between groups using a two-tailed Student t-test for group means.

Table 6 – Daily source of dietary energy (%) of 34 young men that provided under- and acceptable self-report over 4 days food record

Energy source	Under-reports[1] (n = 7)[2]		Acceptable reports (n = 27)	
Proteins	18.6 ± 5.1	(13.7 - 27.9)[3]	17.8 ± 3.5	(12.3- 28.8) n.s.
Total Fat	32.5 ± 4.9	(25.4 - 38.7)	31.9 ± 5.2	(18.5- 40.6) n.s.
Saturated	11.7 ± 2.5	(9.2 - 15.9)	13.1 ± 3.1	(6.1 - 18.9) n.s.
Polyunsaturated	5.3 ± 0.9	(4.6 – 7.0)	4.3 ± 0.9	(2.4 – 5.9) *
Monounsaturated	12.6 ± 2.4	(8.9 - 16.3)	11.8 ± 2.2	(7.5 - 16.0) n.s.
Carbohydrates	47.0 ± 9.0	(36.3 - 57.1)	46.6 ± 6.6	(32.8 - 61.5) n.s.
Alcohol	1.4 ± 2.2	(0.0 - 5.8)	3.7 ± 5.0	(0.0 - 16.5) n.s.

[1] Under-reports (EI / EE < 0.62) and acceptable reports (0.62 EI / EE 1.38).
[2] Number of participants.
[3] Mean ± sd (minimum – maximum).
n.s. P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between groups using a two-tailed Student t-test for group means.

Table 7 – Daily vitamin and mineral intake of 34 young men that provided under- and acceptable self-report by 4 days food record

Dietary intake	**Under-reports [1] (n = 7) [2]**	**Acceptable reports (n = 27)**
Thiamin (mg)	2.5 ± 2.2 (0.9 - 7.3) [3]	2.4 ± 1.4 (0.9 - 7.9) [n.s.]
Riboflavin (mg)	2.8 ± 1.9 (1.5 - 6.9)	2.9 ± 1.2 (1.1 - 6.1) [n.s.]
Niacin (mg)	25.9 ± 9.4 (13.9 - 42.7)	28.7 ± 6.3 (15.6 - 42.4) [n.s.]
Niacin Eq (mg)	44.0 ± 11.4 (26.6 - 59.1)	53.0 ± 11.1 (35.4 - 76.3) [n.s.]
Vitamin C (mg)	135.1 ± 82.0 (63.0 - 271.3)	148.0 ± 85.1 (24.0 – 350.1) [n.s.]
Folate (μg)	296.1 ± 117.7 (156.2 – 516.1)	370.1 ± 123.3 (201.8 – 687.0) [n.s.]
Vitamin A Eq (μg)	707.7 ± 128.5 (499.8 – 884.3)	1048.1 ± 430.6 (508.5 – 1933.7) **
Retinol (μg)	346.9 ± 130.7 (165.9 - 480.7)	527.6 ± 242.6 (246.0 - 1218.8) [n.s.]
B-Caroten Eq (μg)	2157.1 ± 1002.7 (967.5 - 3700.3)	3113.2 ± 1965.6 (576.0 - 8363.4) [n.s.]
Sodium (mg)	488.0 ± 975.4 (107.0 – 2700.0)	117.2 ± 10.5 (101.0 - 135.0) [n.s]
Potassium (mg)	3084.1 ± 654.0 (2445.6 - 3981.7)	3781.6 ± 1101.9 (1786.5 - 7637.5) [n.s.]
Magnesium (mg)	312.8 ± 63.1 (237.2 – 418.0)	392.6 ± 110.5 (233.7 - 670.5) [n.s.]
Calcium (mg)	857.6 ± 209.0 (480.0 - 1067.3)	1211.7 ± 480.9 (417.2 - 2193.5) [n.s.]
Phosphorus (mg)	1440.5 ± 165.0 (1125.3 - 1601.6)	2001.7 ± 449.5 (1202.4 - 2720.2) **
Iron (mg)	12.9 ± 2.7 (10.1 - 17.9)	15.9 ± 4.5 (9.0 - 27.7) [n.s.]
Zinc (mg)	10.7 ± 2.6 (6.8 - 14.4)	15.3 ± 4.5 (9.3 - 29.1) *

[1] Under-reports (EI / EE < 0.62) and Acceptable reports (0.62 EI / EE 1.38).
[2] Number of participants.
[3] Mean ± sd (minimum – maximum).
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between groups using a two-tailed Student t-test for group means.

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CHAPTER 3

BODY COMPOSITION, FOOD INTAKE, PHYSICAL FITNESS, AND PHYSICAL ACTIVITY IN AUSTRALIAN YOUNG MEN

INTRODUCTION

When energy intake (EI) matches energy expenditure (EE), the weight is stable. The total EE, measured over a 24-hour period, has three components: a) the basal metabolic rate (BMR), which typically accounts for about 60 to 70% of total EE, represents the minimal rate of EE that is necessary to support vital functions such as the work of breathing, circulation of blood, maintenance of body temperature, etc; b) the thermic effect of food or dietary thermogenesis represents the EE for eating, digesting, absorbing, transporting, metabolizing, and storing useable forms of energy derived from food and generally represents about 10% or total EE; and, c) EE on physical activity (PA) which is the most variable (Keim *et al.*, 2004).

Increasing EI, decreasing physical activity, or altering both simultaneously unbalance the energy equation in the direction of weight gain. The human body has ability to regulate energy in that EI can be adjusted to EE and vice versa. However, this ability is not sufficient to completely counter the effects on EI, and a chance in body mass results. The rapid increase in the prevalence of obesity through the world suggests that the environment factors are exerting constant pressure to increase EI and decrease EE.

According to World Health Organization (WHO, 2002), an estimated 1 billion people across the world are now overweight or obese and 18 million children under the age of 5 are overweight and these children are at an increased risk of developing dyslipidemia and hypertension as early as their teen years. Data from a national sample of 11247 Australians aged 25 years examined in 2000 revealed that 39.0% of Australian adults were considered to be overweight (body mass index (BMI) of 25.0 – 29.9 $kg.m^{-2}$) and 20.8% obese (BMI 30.0 $kg.m^{-2}$) (Dalton *et al.*, 2003).

Any level of overweight appears to increase cardiovascular disease risk. Greater obesity (Ouyang *et al.*, 2004), body fatness (DuRant *et al.*, 1993) or abdominal obesity (Ward *et al.*, 1994), greater the risk to develop cardiovascular disease (CVD).

CVD is a leading cause of global mortality, accounting for almost 17 million (30%) deaths annually (Bonow *et al.*, 2002; Smith *et al.*, 2004). The rate of CVD is accelerating and one of the causes is the explosive increase in the prevalence of obesity with its related complications of hypertension, hyperlipidemia and atherosclerotic vascular disease (Bonow *et al.*, 2002). Besides obesity, the CVD risk factors include high blood pressure, high serum LDL cholesterol, low level of HDL cholesterol, elevated glucose, insulin resistance, advancing age, tobacco smoking, physical inactivity, atherogenic diet, socioeconomic and psychosocial stress, family history of premature CVD, and various genetic and racial factors (Ball *et al.*, 2003; Smith *et al.*, 2004). Aerobic fitness is also an important independent predictor of CVD in middle-aged men and moderate fitness seems to protect against the influence of other predictors of mortality in adults (Blair *et al.*, 1995; Blair *et al.*, 1996; Wedderkopp *et al.*, 2003). A prospective study in 9777 men ranging in age from 20 to 82 years, with two clinical examinations with a mean interval between examination of 4.9 years, showed that the highest age-adjusted all-cause death rate was observed in men who were unfit at both examinations and the lowest death rate was in men who were physically fit at both examination. Men who improved from unfit to fit between the first and subsequent examinations had a reduction in mortality risk of 44% (Blair *et al.*, 1995).

To adopt the correct interventions to decrease obesity and CVD the objective of this study was to quantify blood lipids, body composition, food intake, PA and cardiovascular fitness in Australian young men.

METHODS

Sample and study design: Thirty eight healthy men aged 18 to 25 y, from the local community in the city of Brisbane, Australia volunteered for the study. The participants were selected at random. Queensland University of Technology Human Research Ethics Committee approved the participant recruitment and the data collection procedures.

Anthropometric measurements: was taken with the participant wearing light and comfortable clothes. Body weight and height was assessed in the participants without shoes using in a digital scale (Tanita BWB-600 Wedderburn) to the nearest 0.1 kg and a stadiometer to the nearest 0.1 cm, respectively. Waist circumference (WC) was measured at the level of the narrowest point between the lower costal border and the iliac crest; umbilicus circumference at the level of the umbilicus and hip circumference at the level of the greatest posterior protuberance of the buttocks. Each circumference measurement was measured three times and the average of the two closest were used in the analysis. All measurements were taken by the same investigator.

Skinfold measurements was measured with Harpenden skinfold calliper held in the right hand, and applied 1 centimetre below the fold raised by the left hand at the level of the premarked site. The reading was taken between 1 and 2 seconds after application of the callipers when the needle slowed. Each skinfolds (triceps, subscapular, biceps, midaxillary, iliac crest, supraspinale, abdominal, thigh, medial calf and chest) was measured three times at standard sites on the right side of the body according to recommendations of International Society for the Advancement of Kinanthropometry, recognised by Australian Association for Exercise and Sports Science and the Australian Sports Commision. The average of the two closest measurements was used in the analyses.

BMI was calculated as weight (kg) divided by height^2 (m^2). Waist hip ratio (WHR) was calculated as waist circumference divided by hip circumference. Trunk skinfolds was calculated as sum of subscapular, iliac crest and abdominal skinfolds. Extremity skinfolds was calculated as sum of biceps, triceps and medial calf skinfolds.

Body composition: was measured by dual-energy X-ray absorptiometry (DEXA) (DPX-Plus; Lunar Corp, Madison, WI). The participant removed shoes any materials that could attenuate the x-ray beam, such jewellery, watches and clothes with zippers and laid on his back in the centre of the table. Participants remained motionless in the supine position while the scanning arm of the DEXA passed over their body from head to toe in parallel 1-cm strips. DEXA measurements were made using a constant potential x-ray source of 76 kVp and a cerium filter that produces dual-energy peaks of 38 and 62 keV. The soft tissue mass (fat and lean tissue) is measured pixel-by-pixel as a beam of photons penetrates the participant's body. When the two beam energies pass through the body they attain a certain degree of attenuation depending on the mass and type of tissue. The ratio of the mass attenuation coefficients of soft tissue varies linearly with the fatty fraction, which is calculated from measurements in all pixels containing only soft tissue (Svendsen *et al.*, 1993). Normal scan mode takes approximately 27 minutes. Quality assurance was assessed by analysing a phantom spine provided by the company, and daily calibrations were performed before scans using a calibration block provided by the manufacturer. Using the DPX-L adult software, version 1.33 (Lunar Corp) it is possible to divide the total body scans in regions of interest and to analyse body composition including fat mass, lean tissue and bone mineral content. Fat free mass (FFM) was defined as the sum of fat-free soft tissue and bone mineral content from the whole-body scan. Trunk, leg, arm and three abdominal regions were manually defined. The abdomen regions were L_1 – L_4 region, located between upper of lumbar vertebrae 1 (L_1) and upper of lumbar vertebrae 4 (L_4); L_2 – L_4 region, located between upper of lumbar vertebrae 2 (L_2) and upper L_4 and 5 cm at L_4, a rectangle of 5 cm of height at upper L_4. Laterally the regions 1, 2 and 3 were defined as to any trunk soft tissue (T) or as the continuation of the lateral sides of the rib cage (C) (Bertin *et al.*, 2000). All DEXA data were collected by the same investigator.

The DEXA values were used to classify the subjects in two groups: a) non-obese (body fat < 20%) and b) obese (including overweight and obese) (body fat 20%). In men, obesity in young to middle-aged subjects (BMI > 30 $kg.m^{-2}$) corresponds with body fat percentage values of more than 25% in males (WHO, 1995; De Lorenzo *et al.*, 2003).

Blood lipids: Following an overnight fast of at least 8 h, a blood sample was collected for total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL C) and triglycerides (TG) determination using reagents from Roche Diagnostics (Indianapolis, IN). The method of determination of TC and LDL-C were based on the determination of ^{4}-cholestenone after enzymatic cleavage of the cholesterol ester by cholesterol esterase, conversion of cholesterol by cholesterol oxidase, and subsequent measurement by Trinder reaction of the hydrogen peroxide formed. To a selective determination of LDL-C in serum, it was used a combination of a sugar compound with detergent. The HDL-C was determined directly in serum using polyethylene glycol-modified enzymes and dextran sulfate. The TG was determined using a lipoprotein lipase for the hydrolysis of triglycerides to glycerol followed by oxidation to dihydroxyacetone phosphate and hydrogen peroxidase. The hydrogen peroxidase reacts with 4-aminophenazone and 4-chlorophenol under the catalytic action of peroxidase to form a red dyestuff (Trinder endpoint reaction). Total cholesterol < 4.0 $mmol.L^{-1}$, LDL-C < 2.5 $mmol.L^{-1}$, HDL-C > 1.0 $mmol.L^{-1}$ and TG < 2.0 $mmol.L^{-1}$ were the target levels (criteria) as suggested by news National Heart Foundation of Australia (NHFA) guidelines (Barter *et al.*, 2001).

Food intake assessment: was assessed by 4 days food record (4dFR). Before the participants started to record, they watched a presentation with 48 slides of food size portion photographs and were given food intake recording sheets and instructions in how to complete them. The period recording included two week days, Saturday and Sunday.

Resting metabolic rate (RMR): Due to challenges for measuring the basal metabolic rate (BMR), RMR, which that represents the amount of EE under restful conditions, was assessed by a continuous open-circuit indirect calorimetry device. Data collection took place in a thermal-regulated environment with minimal light and noise. Participants fasted for 5 hours and minimised physical activity prior to arrival. Participant lay supine in a comfortable position, listening to a radio to prevent sleeping whilst was monitored to ensure that he remained awake. Respiratory gases were collected continuously for 30 minutes and data from the last 10 minutes were used for analyses. Deltatrac II metabolic cart (Datex-Ohmeda Corp., Helsinki, Finland http://www.datex-ohmeda.com) with ventilated canopy was used to assess RMR of half of the participants. The transparent canopy was placed over the head and the expired gas was analysed for oxygen concentration via a paramagnetic O_2 sensor and for carbon dioxide concentration via an infrared absorption technique. Due to technical problems, Moxus O_2 system (AEI Technologies, Pennsylvania, USA) was used to assess the RMR of the remaining participants. Participants were fitted with a Hans-Rudolf headset (with two-way breathing valve and pneumotach) and a nose clip. Both gas analysers were calibrated prior to each measurement against standard mixed reference gases. The Weir equation (Weir, 1949) was used to convert O_2 and CO_2 values to RMR values.

$$RMR = [(1.106\ CO_2 + 3.941*O_2] \times 1440\ min.d^{-1}$$

Where, RMR is the resting metabolic rate ($kcal.d^{-1}$), CO_2 is the carbonic dioxide production rate ($L.min^{-1}$) and O_2 is the oxygen consumption rate ($L.min^{-1}$).

Energy expenditure: was assessed by physical activity records over four days (two weekdays, Saturday and Sunday) simultaneously recording food intake. Participants were instructed to record the scores (1 – 9, corresponding to nine categories of PA intensity) for each 15-min period, throughout the day. The average EE for each category and their corresponding list of activities have been established by Bouchard *et al*. (1983) These categories were explained and illustrated in detail to each participant before they started to record. EE was calculated multiplying the MET (metabolic equivalent) of each score by RMR calculated to each participant. The physical activity levels (PAL) were classified as light (EE < 3 MET), moderate (3 EE < 6 MET) and intense (EE 6 MET), according to the CDC-ACSM's (Center for Disease Control and Prevention of the American College of Sports Medicine) position statement (Bouchard *et al.*, 1983; Dionne *et al.*, 2000).

Cardiorespiratory fitness: was measured on a treadmill using a speed continuous, grade incremental running test. Participants worn light weight, comfortable clothing and shoes, had abstained from strenuous exercise in the previous 24 hours and from food intake in the previous 3 hours. Participants were fitted with a Polar Coded Transmitter™, a receiver (Polar Electro, Kempele, Finland), a Hans-Rudolf headset (with two-way breathing valve and pneumotach) and a nose clip. After a 4-min warm-up at 3.5 mph, 0% grade, speed was increased to comfortable speed, which was the same until the end of the test. The comfortable speed, defined to each participant about one week prior to treadmill test, ranged from 4 to 6.5 mph. Thereafter, the treadmill slope was increased by 2% every min, till the participants exhaustion. Participants were urged to give a maximal effort and were motivated to volitional fatigue. The rating of perceived exertion using the Borg scale was obtained during each stage and participant were encouraged to achieve a rating of 18 or higher as an indicator of maximal effort. The maximal oxygen uptake (VO_{2max}) was assessed by a MOXUS Modular O_2 System

(AEI Technologies, Pennsylvania, USA). Heart rate (HR), carbon dioxide production (CO_2) and oxygen consumption (O_2) rates were recorded every 5s throughout the test. The O_2 and CO_2 analysers were calibrated prior to each test against known gas concentrations and the flow meter calibrated against a 3.0-L syringe. The participants achieved the VO_{2max} when a difference between the last 2 completed stages determined by average from last 30 second period before increase load was less than 1.6 $ml.kg^{-1}.min^{-1}$ or when both HR ± 10 bpm of 220 – age and respiratory exchange ratio (RER) > 1.15 were achieved (Howley *et al.*, 1995). The VO_{2max} was defined as the highest observed value averaged from 15 seconds in a completed stage. When the participant did not get the VO_{2max}, the VO_2 peak oxygen uptake (VO_{2peak}), the highest observed value of VO_2 was considered in analysis. HR peak was defined as the highest HR recorded. VO_2 was expressed relative to body weight values. At the termination point the grade was eliminated and each participant continued to walk until heart rate returned to pre-exercise levels. The criteria (HR ± 10 bpm of 220 – age) used to identify maximal HR was chosen because it is the most used. However according to Tanaka *et al.* (2001) this criteria is not the most recommended.

RESULTS AND DISCUSSION

Body composition

Obese (body fat 20%) had higher body weight, BMI, circumference measurements and WHR than non-obese men (body fat < 20%). Non-obese and obese men had similar fat free mass, but non-obese men had proportionally more FFM than obese men. The participants of the current study have similar anthropometric characteristic to those of a survey conducted in Australia (Table 1).

The percentages of overweight and obese men, according to BMI, found in the current study are higher than those found in surveys done in 1995 (McLennan and Podger, 1995) or in 2000 (Armstrong *et al.*, 2000b) (Table 2). Although BMI is often used to classify subjects in relation to degree of obesity and age- and health-related changes in body composition, this index has limitations and should not be used alone (Wong *et al.*, 2004). In the current study, three participants non-obese, with body fat percentage ranging from 12.5 to 19.2%, had BMI higher than 25 $kg.m^{-2}$. The great percentage of muscle mass, which is heavier than fat mass, account to heavier weight resulting in BMI higher than 25 $kg.m^{-2}$. On the same way, 5 participants with BMI < 25 kg.m^{-2} had body fat > 20%. In addition, BMI does not account for variation in body fat distribution and abdominal fat mass. Excess intra-abdominal fat is associated with greater risk of obesity-related morbidity than is overall adiposity (Dalton *et al.*, 2003). Abdominal obesity has been indicated by waist circumference and waist hip circumference ratio (WHR). According to the new National Heart Foundation of Australia guidelines, men should have waist circumference and WHR less than 90 cm and 0.90, respectively (Barter *et al.*, 2001). Even among obese men of the current study, the mean waist circumference and WHR were lower than the recommended limits (Table 1). Among the participants of the current study, 21.6% and 2.7% had waist circumference and WHR, respectively, higher than the recommended limits.

Body fat percentage of the participants of the current study was similar to those from other studies using DEXA to assess body fat in men with similar characteristics such as age and BMI, but lower when compared to older men (Table 3). Higher body fat percentage has been observed in older than younger people (Tahara *et al.*, 2002; Nassis and Geladas, 2003; Ferreira *et al.*, 2005).

The participants of the current study had huge ranging of body fat mass not only for total body but also for segmental parts (Table 4). Similar body fat ranging and values have been found in other studies. Among 17 men aged 25 to 53 y with body weight ranged from 58.5 to 87 kg and BMI from 20.4 to 28.3 kg.m^{-2}, Kamel *et al.* (1999) found body fat ranging from 8.1 to 30.5 kg. Park *et al.* (2002) found mean trunk fat of 7.48 kg, ranging from 1.09 to 20.25 kg in men aged 18 to 44 y having mean BMI of 24.6 kg.m^{-2}. The central abdominal fat quantified in participants of the current study was similar to those found in other studies independent of defined abdominal region. Kamel *et al.* (1999) found 1.13 ± 0.34 kg (0.31 to 1.8 kg) of fat in central abdominal region defined as 5 cm at L_3 and laterally as the continuation of the lateral sides of the rib cage, in 17 men aged 25 to 53 y. Park *et al.* (2002) found 1.41 ± 0.83 kg of fat, ranging from 0.17 to 3.94 kg in central abdominal region defined as upper L_2 and lower L_4 and width extending to the lateral margins of the image in men aged 18 to 44 y having mean BMI of 24.6 kg.m^{-2}. The similarity of quantity of fat found in participants of the current study and of others even when the localization of the region of same size (width and height of rectangle) was different may be due to the high correlation coefficient among total and segmental fat percentage (Table 5).

Obese and non-obese had similar lean mass and bone mineral content. More than 70% of bone mineral content and more than 80% of lean mass are on leg and trunk together (Table 4). The overall mean bone mineral content found in participants of the current study is similar to those found by Armstrong *et al.* (2000a), where 77 men had mean BMC of 3.17 ± 0.04 at 18.8 y and of 3.40 ± 0.05 kg 3.4 years after. The minimum and maximum BMC were 2.26 at 18.8 y and 5.08 kg at 22.2 y, respectively (Armstrong *et al.*, 2000a).

In the current study, as expected, all measurements of skinfolds were higher in obese than in non-obese men (Table 6). The similarity in skinfold measurements between the participants of current study and of other studies was observed in isolated measurements and in sum of specific skinfold, such as trunk skinfolds (abdominal, supra iliac and subescapular) (Doucet *et al.*, 1998), limb (triceps, biceps, front midthigh, suprapatellar and medial calf) (Bouchard *et al.*, 1990), sum of six skinfolds (triceps, biceps, abdominal, supra iliac, subescapular and medial calf) (Doucet *et al.*, 1998) and sum of seven skinfolds (triceps, abdominal, supra iliac, subscapular, chest, thigh and midaxilliary) (Tahara *et al.*, 2002).

Blood lipid levels

In the current study, the mean TC and LDL-C levels were above the target levels of 4.00 $mmol.L^{-1}$ and 2.50 $mmol.L^{-1}$ (Barter *et al.*, 2001), respectively, even among non-obese. These high values of blood lipids have been also observed in other studies with men (Table 7). The TC / HDL-C and LDL-C / HDL-C ratios are also similar to 3.24 ± 0.07 and 1.92 ± 0.07, respectively, found among 104 male adolescents aged 10 to 19 y (Eisenmann *et al.*, 2003). Obese had lower HDL-C, higher TG, higher TC / HDL-C and higher LDL-C / HDL-C than non-obese men (Table 7). Obesity, abdominal obesity and visceral fat have been positively associated with higher TC (DuRant *et al.*, 1993), LDL-C (DuRant *et al.*, 1993; Ward *et al.*, 1994), TG (Ward *et al.*, 1994; Nguyen-Duy *et al.*, 2003) , TC / HDL-C (Nguyen-Duy *et al.*, 2003) and negatively associated with HDL-C levels (Summers *et al.*, 2002; Nguyen-Duy *et al.*, 2003).

Higher percentage of obese participants had blood lipid levels above target levels compared to non-obese participants independent of the criteria (Table 8). An analysis of national estimates from the 2001 National Health Survey reveled that more obese men (BMI > 30 $kg.m^{-2}$) reported having high cholesterol than non-obese men (BMI < 25 $kg.m^{-2}$) (12.9% x 8.4%) (AIHW *et al.*, 2004). In the current study, the highest percentage of participants above target blood lipid levels were identified by the

TC criteria (TC > 4.0 $mmol.l^{-1}$). The different target blood lipid levels among the studies (Table 8) makes hard to compare. When lower TC, LDL-C and TG values are used to identify CVD risk, higher percentage of people will be identified in risk.

The evidence linking CVD to plasma total cholesterol and low-density lipoproteins (LDL-C) is essentially the same as most of the cholesterol in plasma is transported as a component of LDL. The mechanisms by which LDL cause atherosclerosis and by which existing atherosclerotic plaques become unstable are now reasonably well understood. Plasma LDL cross the endothelial layer, enter the subendothelial space and slowly accumulate. The LDL in the subendothelial space become modified by chemical changes that lead to an accumulation of cholesterol in the macrophages, which are converted into foam cells, that lead to progression of the atherosclerotic plaque (Barter *et al.*, 2001). HDL may protect against the development of atherosclerosis proportioning cholesterol efflux from cells minimizing the accumulation of foam cells in the artery wall. The proteins of HDL, have antioxidant properties inhibiting the oxidative modification of LDL and may thereby reduce the atherogenicity of these lipoproteins. Triglyceride present in chylomicrons and very low-density lipoproteins appears to be non-atherogenic (Barter *et al.*, 2001).

Food intake

The type and quantity of food eaten determines the daily nutrient intake. All people need the same range of nutrients. However, the quantities required depend on age, sex, physical size, state of health and physical activity levels. The macronutrients (protein, fat and carbohydrate) contained in foods eaten provide the energy needed for physical activity, and for keeping organs working, replacing cells, repairing damage and building tissue. Vitamins and minerals also play an important role in our health and well-being.

A well balanced diet should contain adequate amounts of protein, fat, carbohydrate, vitamins, minerals, and water. The largest proportion (50-60%) of the daily EI should be in the form of carbohydrates. Approximately 12 to 20% of daily EI should be protein. A total fat intake of less than 30% of the daily EI is recommended. Over 90% of fats in the diet and in the body are in the form of triglycerides, which are made up of glycerol and fatty acids. Fatty acids are classified according to the number of double bonds they possess. Saturated fatty acids contain no double bond, monounsaturated fatty acids (MUFA) contain one and polyunsaturated fatty acids

(PUFA) contain two or more. Saturated and monounsaturated fatty acids are synthetized by body to provide an adequate level needed for their physiological and structural functions and they have no know role in preventing chronic diseases, and therefore are not required in the diet. On the other hand, the consumption of the PUFA, linoleic acid and -linolenic acid, is associated with beneficial health effects.

The mean EI of the participants of the current study, was lower than those found among men from a survey (Table 9) but similar to those found in other studies in men with similar age and BMI. Among 29 men aged 22 to 49 y, with BMI ranging from 22.5 to 30.9 $kg.m^{-2}$, daily mean EI was 2756.3 ± 867.7 kcal, ranging from 1589.6 to 3605.1 kcal (Basiotis *et al.*, 1989). Among 25 men aged 30 y, with mean BMI of 24.0 ± 2.9 $kg.m^{-2}$, daily mean EI was 2557 kcal (Johansson *et al.*, 2001).

The similar mean EI in obese and non-obese (< 20% of body fat) men observed in the current study (Table 9) have been observed in other studies (Baecke *et al.*, 1983; Andersson and Rossner, 1996). Even a lower EI (2482.7 x 2814.4 kcal) in obese (BMI > 30 $kg.m^{-2}$) than in non-obese men (BMI of 20 to 25 $kg.m^{-2}$) aged 19 to 24 y have been observed (McLennan and Podger, 1995). When EI was divided by weight body, obese had lower EI (30.8 ± 7.2 $kcal.kg^{-1}$) than non-obese men (38.9 ± 8.4 $kcal.kg^{-1}$) in the current study. Miller (1991) found that non-obese consumed more energy than obese, when EI was expressed in $kcal.kg^{-1}$ total weight body. A lower EI in obese than in non-obese may indicate underreporting of food consumption during the food intake reported period, which have been positively associated with obesity (Mertz *et al.*, 1991; Heitmann and Lissner, 1995; Briefel *et al.*, 1997; Johansson *et al.*, 1998; Brunner *et al.*, 2001; Johansson *et al.*, 2001; Hoidrup *et al.*, 2002; Samuel-Hodge *et al.*, 2004).

The similar eating pattern between obese and non-obese men observed in the current study (Table 9) was also observed by Rossner (1996). The mean carbohydrate, protein and fat intakes reported by the participants of the current study were lower than those reported by participants of survey in 1995, in absolute values, but not in relative values for EI. Carbohydrate contributed for less than 50% of EI, fat contributed for more than 30% of EI and only 10 participants consumed less than 30% of fat from EI (Table 9). Among 122 men aged 20 to 32 y, with 16.8 ± 4.5% of body fat, Baecke *et al.* (1983) found that carbohydrate, protein, fat and alcohol contribute to 44.4%, 12.6%, 37.7% and 5.3% of EI, respectively. The mean contribution for EI of saturated fatty acids, MUFA and PUFA intakes were 16.9%, 14% and 5.8%, respectively (Baecke *et al.*, 1983).

Several essentials nutrients have recommended daily levels for maintenance of good nutrition in healthy, normally active persons. Recommended dietary allowance (RDA) are the levels of intakes of essential nutrients, considered in the judgment of the National Health and Medical Research Council (NHMRC), to be adequate to meet the nutrient requirement of nearly all (97 to 98%) healthy individuals in a group. In addition to RDA, there are three additional reference values, the estimated average requirement (EAR), the adequate intake (AI) and the upper limit (UL). The EAR is a nutrient intake value that is estimated to meet the requirement of half the healthy individuals in a group. The AI is a recommended daily intake level based on observed or experimentally determined approximations of nutrient intake by a group of healthy people. The upper limit (UL) intake is the highest level of daily nutrient that is likely to pose no risks of adverse health effects to almost all individuals in the general population (Yates *et al.*, 1998). A safe range of intake for each nutrient in all population groups should be between RDA and UL.

There is not AI, RDA or UL for monounsaturated and saturated fatty acids. Any incremental increase in saturated fat intake increases CVD risk. It is neither possible nor advisable to achieve 0 percent of energy from saturated fat in typical whole-food diets. Because saturated fatty acids are unavoidable in ordinary diets, consuming 0 percent of energy would require extraordinary changes in patterns of dietary intake. There is not AI, RDA or UL for PUFA as well, but there is AI for linoleic acid and -linolenic acid, which are 17 $g.d^{-1}$ and 1.6 $g.d^{-1}$, respectively, for young men. Usually the software of food intake analysis does not consider PUFA divided in linoleic acid and -linolenic acid. The Food and Nutrition Board of the National Academies (Lupton *et al.*, 2002) suggest that a minimum intake of 18.6 $g.d^{-1}$ of PUFA (17 $g.d^{-1}$ + 1.6 $g.d^{-1}$). In the current study, the mean intake of PUFA was lower than this recommendation (Table 9). Only 2 participants had PUFA intake higher than 18.6 $g.d^{-1}$.

The mean consumption of dietary fiber reported by participants of the current study (Table 9) was similar to those reported in survey done in 1995 (McLennan and Podger, 1995) but below to 38 $g.d^{-1}$ which is recommended fiber intake for men 50 y and younger (Trumbo *et al.*, 2002). In the current study, only two participants among 36 had fiber intake above the recommended. Baecke *et al*. (1983) found mean fiber intake of 29.1 $g.d^{-1}$ among 122 men aged 20 to 32 y.

The mean vitamin and mineral intake found in participants of the current study is similar to those found in a survey done 1995. All mean vitamins and mineral intakes were between RDA and UL, except to niacin equivalent (Table 10). Only 9% of the participants of the current study had their niacin intake below UL. As Australia has not stated the UL for nutrients, the UL to the current study were those for United States and Canada set by the Food and Nutrition Board of the Institute of Medicine (Yates *et al.*, 1998). The most important sources of niacin were meat, bread, baked beans, breakfast cereal, peanut butter and vegemite. The last one is a yeast extract, typical Australian food.

Respiratory exchange ratio

Resting respiratory quotient or the fasting respiratory exchange ratio (RER) (carbon dioxide production divided by oxygen consumption) during resting indicates the fasting glucose to fat oxidation ratio. In the post-absorptive state glucose is the obligatory oxidation substrate for the central nervous system and the only significant supplier of glucose for peripheral utilization is the liver (70 – 80% from glycogenolysis and 20 – 30% from gluconeogenesis). In the fasting state, the fatty acids are oxidized to supply glucose (Seidell *et al.*, 1992). A low fasting RER reflects relatively low glucose oxidation after an overnight fast. This implies relatively reduced glycogen storage and / or reduced gluconeogenesis in comparison to those with a relatively high fasting RER. Persons with a lower RER were less likely to experience weight gain in subsequent years maybe because they oxidize more stored fat than those with a high RER (Seidell *et al.*, 1992; Blundell and Cooling, 2000). In the current study, obese and non-obese had similar RER (Table 11), which was also similar to those found in others. DeLany *et al.* (2004) also found that obese (body fat > 25%) and non-obese (body fat < 25%) adolescents aged 12 y had similar RER. Sharp *et al.* (2002) found RER of 0.78 for 95 men with mean age of 35.2 ± 0.39 y and body fat percentage of 24.8 ± 0.84%. Ravussin *et al.* (1982) found RER ranging from 0.78 to 0.83 not only among non-obese men (body fat ranging from 16.4 to 19.9%) but also among obese (body fat ranging from 27 to 32.2%) men.

Resting metabolic rate

Basal metabolic rate (BMR) or the resting metabolic rate (RMR) is the major component of EE. The mean RMR among young men found in the current study (Table

11) is similar to that found in other studies. Hise *et al.* (2002) found RMR of 2067.4 ± 205.5 kcal for 22 men with mean age of 22.7 ± 3.8 y and body fat percentage of 28.1 ± 4.1%. Goran *et al.* (1994) found RMR of 1760.6 ± 232 kcal for 19 men with mean age of 25 ± 5 y and body fat of 10.4 ± 6.3 kg. Westerterp-Plantenga *et al.* (2003) found a RMR of 1840 kcal among 19 men of 23.1 ± 2.9 y of age and with 15.2 ± 3.1% of body fat. When data sets from 22 different studies were analysed, Westerterp and Goran (1997) found a BMR ranging from 1458 to 2318 kcal among 54 men with age ranging from 19 to 46 y and body fat ranging from 8 to 37%. When men with body fat ranging from 3 to 60% were considered, the BMR ranged from 1410 to 3035 kcal (Westerterp and Goran, 1997). The determinants of RMR include FFM, which is the most important, age, familial trait (Bogardus *et al.*, 1986; Jorgensen *et al.*, 1998) and race (Sharp *et al.*, 2002).

Higher RMR have been observed in obese than in non-obese people (Prentice *et al.*, 1986; Seidell *et al.*, 1992; Ekelund *et al.*, 2002; DeLany *et al.*, 2004). However, in the current study, obese and non-obese had similar RMR (Table 11) likely due to similar amount of fat free mass (Table 1) as FFM can contribute to 80% of RMR (Bogardus *et al.*, 1986).

Physical activity

The similar RMR between non-obese and obese men may be contributed to similar EE found in the current study (Table 11). However, higher EE in obese than in non-obese have been found not only in adults (Prentice *et al.*, 1986) but also in children (DeLany *et al.*, 2004). But in both studies, RMR was higher in obese than in non-obese people. The mean daily EE found in the current study (Table 11) was similar to those found in other studies. Conway *et al.* (2002) found that 21 men aged 27 to 65 y with BMI ranging from 20.9 to 31.5 $kg.m^{-2}$ expended daily 3171 kcal assessed by PA records over 7 days. Barnard *et al.* (2002) found daily EE assessed by DLW of 4115 kcal among 4 men aged 26 to 59 y, with BMI ranging from 20.1 to 32.7 $kg.m^{-2}$. Cole and Ogbe (1987) found EE assessed by DLW, ranging from 1711 to 2930 kcal among 20 men aged 20 to 30 y, with body weight ranging from 51 to 69.5 kg. When data sets from 22 different studies were analysed, Westerterp and Goran (1997) found a daily EE assessed by DLW, ranging from 2246.7 to 4708.4 kcal among 54 men with age ranging from 19 to 46 y and body fat ranging from 8 to 37%.

Physical activity level (PAL) is EE divided by BMR. Light, moderate and heavy activity level for men correspond to 1.56, 1.78 and 2.10, respectively (FAO/WHO/UNU, 1985; Conway *et al.*, 2002). The PAL ranging from 1.40 to 2.28 (Table 11) meaning that the participants of the current study had activity ranging from light to intense is similar to those found in other studies. Conway *et al.* (2002) found PAL ranging from 1.58 to 2.05, assessed by PA records over 7 days, among 21 men aged 27 to 65 y with BMI ranging from 20.9 to 31.5 $kg.m^{-2}$. When data sets from 22 different studies, where EE was assessed by DLW were analysed, Westerterp and Goran (1997) found a PAL ranging from 1.35 to 2.24 among 54 men with age ranging from 19 to 46 y and body fat ranging from 8 to 37%.

According to Sallis *et al.* (1988), energy expended in daily PA should be at least 80% of the RMR. In the current study, 26.3% of the participants spent less than this recommendation in daily PA. The percentage of energy expended in daily moderate or intense PA in relation to RMR among the participants of the current study ranged from 40% to 126.3% (Table 11).

Similar PAEE, when corrected by BW (Prentice *et al.*, 1986) or FFM (Ekelund *et al.*, 2002), between obese and non-obese have been observed not only in adults (Prentice *et al.*, 1986) but also in children (Ekelund *et al.*, 2002). However, when EE was not corrected by BW (Prentice *et al.*, 1986) or FFM (Ekelund *et al.*, 2002), obese had higher EE than non-obese. The increased energy cost of moving a larger body mass and a difference in movement economy, as suggested by Ekelund *et al.* (2002) to explain their results, may be contributed to the same EE or PAEE between obese and non-obese men observed in the current study, only when these values were not corrected by BMI or BW (Table 11).

The higher PAEE / BW in non-obese men observed in the current study likely was due to more time doing moderate and intense activity and less time doing light activity than obese men (Table 12). Ekelund *et al.* (2002) also observed that non-obese spent more time at a physical activity of moderate intensity than obese adolescents and suggested that this time, but not the PAEE, might be associated with obesity and its development.

Higher physical activity provides a wide range of benefits, including lower risk of developing chronic diseases such as diabetes and CVD (Keim *et al.*, 2004; Zhu *et al.*, 2004). For decrease risk of developing chronic diseases, it is necessary to accumulate a minimum of 30 minutes of moderate PA on most, if not all, days of the week (Keim *et al.*, 2004). If the weight control is desired, the minimum recommended is at least 60 minutes of moderate or intense PA per day (Keim *et al.*, 2004). In the current study, the mean time spent in moderate and intense activity, over 4 recorded days, was higher than 30 min not only in non-obese but also in obese men (Table 12). Among 38 participants, only one spent less than 30 $min.d^{-1}$, and 5 of them spent less than 60 $min.d^{-1}$ of moderate or intense PA. A survey done in November of 1999 showed that among 1512 Australian men aged 18 to 29 y, 74% spent at least 30 min of moderate or intense PA during 5 days per week (Armstrong *et al.*, 2000b). The current physical activity guideline for adults of 30 minutes of moderate intensity activity daily, preferably all days of the week, according to report of the Surgeon General Guidelines (Anonimous 1996), is of importance for limiting health risks for a number of chronic diseases including coronary heart disease and diabetes. However for preventing weight gain or regain this guideline is likely to be insufficient for many individuals in the current environment. There is compelling evidence that prevention of weight regain in formerly obese individuals requires 60–90 minutes of moderate intensity activity or lesser amounts of vigorous intensity activity (Saris *et al.*, 2003). The time spent in various activities by the participants of the current study is similar to those from other studies. Male students from Nigeria slept on average 8.2 $h.d^{-1}$ (Cole and Ogbe, 1987). A survey done in November of 1999 men aged 18 to 29 y spent in average 111.3 $min.d^{-1}$, 59.3 $min.d^{-1}$ and 202.5 $min.d^{-1}$, walking, in moderate PA and in intense PA, corresponding to < 3 MET, 3 – 5 MET and > 5 MET, respectively. Eisenmann *et al.* (2003) found that the least, moderate and the most active adolescents aged 10 to 19 y spent in average 43.5, 129.0 and 271.5 $min.d^{-1}$, respectively in moderate and vigorous activity (> 4.8 MET) when EE was assessed by PA records.

Cardirespiratory fitness

Aerobic capacity, as measured by maximal oxygen consume (VO_{2max}) is one of the fundamental components of physical fitness (Berthouze *et al.*, 1995). The mean VO_{2max} found in the current study (Table 14) is similar to those found in other studies. The mean VO_{2max} of 6 men aged 26.3 ± 2.5 y, with 15.40 ± 2.67% of body fat was 47.75 ± 1.84$ml.kg^{-1}.min^{-1}$ (Ho *et al.*, 2002). Among men aged from 18 to 31 y, with body fat percentage ranging from 10 to 32%, the VO_{2max} ranged from 40 to 70 $ml.kg^{-1}.min^{-1}$ (Santo and Golding, 2003). Among men aged 16 to 73 y, VO_{2max} ranged from 22.9 to 75.3 $ml.kg^{-1}.min^{-1}$ (Berthouze *et al.*, 1995). For men aged 5 to 25 y, the mean

VO_{2max} was 58.7 ± 5.8 ml.kg^{-1}.min^{-1}, regardless the level of physical activity (Berthouze *et al.*, 1995). Berthouze *et al.* (1995) found out that daily EE account for the largest (89.35%) proportion of the VO_{2max} while body mass account for only 0.85% in VO_{2max}. In the current study, obese had lower VO_{2max} than non-obese (Table 14). The decreasing on cardiorespiratory fitness with body fat increasing has also been observed in other studies. Adolescents with low adiposity, assessed by skinfold thickness had higher physical performance capacity assessed by PWC_{170} method than those with high adiposity (Taylor and Baranowski, 1991). In the PWC_{170} method, the cardiorespiratory fitness is expressed as the cycle ergometer gradient at which a heart rate of 170 beats.min^{-1} is reached during a graded exercise test, using a cycle ergometer. Boys aged 17 y with low running performance had higher skinfold measurements and higher waist circumference than those with high running performance assessed with a 3 km running test (Bergstrom *et al.*, 1997). Men classified with VO_{2max} of 29.5 ± 4.2 ml.kg^{-1}.min^{-1} (low cardiovascular fitness) had higher body weight, waist circumference and body fat percentage than those with VO_{2max} of 44.3 ± 5.7 ml.kg^{-1}.min^{-1} (moderate cardiovascular fitness) (Janssen *et al.*, 2004). The non-obese men we an excellent level of fitness (>51) and the obese men was at average level of fitness (42 to 48 ml.kg^{-1}.min^{-1}) when compared with values published by American College of Sports Medicine (ACSM, 1988).

Despite of having lower VO_{2max}, the obese participants had similar heart rate than non-obese participants. According to Santo and Golding (2003), the excess of weight increases heart rate.

In conclusion, the prevalence of obesity found in the current study is similar to those found in other studies in participants with similar characteristics. The mean intake of fat of the participants of the current study were above to the recommendation. The mean intake of carbohydrate, PUFA and dietary fiber reported by participants of the current study was below than the recommendation. Meat, bread, baked beans, breakfast cereal, peanut butter and vegemite were the most important sources of niacin which contributed to the intake higher than the recommendation. The other micronutrients were above the recommendation. An overall, the mean time spent in moderate and intense activity, was higher than the recommendation of 30 min. However, more physical activity of moderate and or intense level should be recommended to some participants who are not spending the recommended minimum time, which will help to increase the cardiorespiratory fitness. The non-obese participants were at an excellent and obese participants were at an average level of fitness. Increasing PA and having a healthy and well balanced diet may help to increase FFM which increase the RMR and consequently the EE. A higher RMR accounts for a higher EE which would account for an imbalance between EI and EE in order to lost weight and therefore to decrease the obesity. The high percentage (68%) of participants above target blood lipid levels found in the current study can be decreased by increased PA and healthy diet. While isolated measurements alone make only a relatively small difference to the risk of early CVD, when combined with other risk factors they make an important difference.

Table 1 - Body composition of young men in the current and another study

Characteristics	**Current study**			**Survey**[2]
	Non – obese[1] **(n= 21)**	**Obese**[1] **(n = 17)**	**All (n=38)**	
Body weight (kg)	70.7 ± 10.2 (54.5 – 87.8)[5]	90.0 ± 23.5 (63.3 – 168.6)*	79.4 ± 19.7	78.3
Age (years)	21.4 ± 1.8 (19.2 – 25.6)	22.5 ± 2.4 (18.0 – 25.8) [n.s.]	21.9 ± 18.0	-
Height (m)	1.75 ± 0.07 (1.60 – 1.89)	1.78 ± 0.07 (1.64 – 1.87) [n.s.]	1.76 ± 0.07	1.78
Body Mass Index (kg.m^{-2})	23.0 ± 2.8 (18.8 – 28.8)	28.4 ± 6.7 (22.8 – 51.8)*	25.5 ± 5.6	24.6
Waist circumference (cm)[3]	78.3 ± 5.2 (69.0 – 89.0)	88.5 ± 8.1 (77.5 – 100.5) **	82.6 ± 8.3	84.4
Hip circumference (cm)[3]	98.9 ± 5.9 (87.5 – 110.0)	107.3 ± 5.7 (99.5 – 117.3) **	102.4 ± 7.1	99.8
Umbilicus circumference (cm)[3]	80.9 ± 5.7 (71.0 – 92.0)	93.1 ± 8.2 (79.5 – 108.0) **	86.13 ± 9.09	-
Waist Hip Ratio[3]	0.79 ± 0.02 (0.75 – 0.83)	0.82 ± 0.05 (0.76 – 0.92) *	0.81 ± 0.04	0.84
Body fat[4] (%)	13.1 ± 4.2 (6.0 – 19.3)	26.1 ± 5.8 (20.3 – 37.6) **	18.7 ± 8.2	-
Fat free mass[4] (kg)	61.3 ± 8.0 (49.4 – 73.6)	62.9 ± 10.1 (46.6 – 79.2) [n.s.]	62.0 ± 8.9	
Fat free mass[4] (%)	86.7 ± 4.2 (80.7 – 93.96)	73.9 ± 5.8 (62.4 – 79.7) **	81.3 ± 8.2	-

[1] Non – obese (body fat < 20%) and obese (body fat 20%).
[2] Data from 866 Australian men aged 19 to 24 y (McLennan and Podger, 1995).
[3] Circumference measurements of 35 (20 non-obese and 15 obese) participants.
[4] Body fat and fat free mass (= bone mineral content + lean mass) from 37 participants (20 non-obese and 17 obese) assessed with DEXA.
[5] Mean ± SD (Minimum – Maximum).
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

Table 2- Obesity (%) according to BMI in young men in the current study and others.

	Current study (n = 38)	Australian surveys	
		1995[1]	**2000**[2]
Underweight (BMI < 20 kg.m^{-2})	10.5	5	7.5
Healthy range (BMI, 20 – 24.9 kg.m^{-2})	47.4	54.8	65.9
Overweight (BMI, 25 – 29.9 kg.m^{-2})	31.6	27.7	19.8
Obese (BMI 30 kg.m^{-2})	10.5	9.9	6.8

[1]It was considered only data from 866 men aged 19 to 24 y (McLennan and Podger, 1995).
[2] It was considered only data from 387 men aged 18 to 29 y (Armstrong *et al.*, 2000b).

Table 3 – Body fat (%) assessed by DEXA in men in the current study and others

Studies	**n**	**Age (years)**	**BMI (kg.m^{-2})**	**Body fat (%)**
Current	37	18 to 25	18.8 to 33.2	18.7 ± 8.2
Ho *et al.* (2002)	6	18 to 40	24.1 ± 0.7	15.4 ± 2.7%
Carter *et al.* (2001)	8	22 ± 1	-	16.0 ± 1.4%
Tothill and Stewart (2002)	8	23 to 49	22.8 to 27.1	16.0 ± 5.2%
Park *et al.* (2002)	19	18 to 44	17.1 to 29.9	18.4 ± 7.0%
Jorgensen *et al.* (1998)	18	40 ± 3	-	19.5 ± 1.8%
Kamel *et al.* (1999)	17	25 to 53	20.4 to 28.3	23.2%

Table 4 – Body fat, bone mineral content (BMC) and lean mass assessed by DEXA in youth men according to body fat percentage

	All (n = 37)	**Non-obese[1] (n = 21)**	**Obese[1] (n = 16)**
Fat (kg)			
Total	14.85 ± 7.93 (3.84 – 36.1) [3]	9.37 ± 3.89	22.04 ± 5.79 **
Arm	1.44 ± 0.87 (0.35 – 3.96)	0.87 ± 0.42	2.18 ± 0.72 **
Leg	5.59 ± 3.0 (1.52 – 13.53)	3.58 1 ±.50	8.22 ± 2.34 **
Trunk	7.00 ± 3.91 (1.65 – 17.31)	4.33 ±1.96	10.52 ± 2.89 **
L_1L_4[2]	1.61 ± 1.16 (0.33 – 4.81)	0.87± 0.41	2.59 ± 1.11 **
L_2L_4[2]	1.28 ± 0.96 (0.25 – 4.03)	0.67 ± 0.34	2.08 ± 0.92 **
5cm at L_4[2]	0.63 ± 0.43 (0.12 – 1.65)	0.35 ± 0.17	1.00 ± 0.38 **
Ribs	0.82 ± 0.33 (0.26 -1.51)	0.60 ± 0.26	1.12 ± 0.77 **
BMC (kg)			
Total	3.38 ± 0.56 (2.38 – 4.52)	3.28 ± 0.50	3.50 ± 0.62 [n.s.]
Arm	0.45 ± 0.09 (0.27– 0.62)	0.44 ± 0.09	0.47 ± 0.09 [n.s.]
Leg	1.29 ± 0.24 (0.84 – 1.68)	1.24 ± 0.22	1.35 ± 0.27 [n.s.]
Trunk	1.12 ± 0.23 (0.77 – 1.62)	1.10 ± 0.21	1.14 ± 0.26 [n.s.]
Head	0.52 ± 0.05 (0.38 – 0.61)	0.50 ± 0.05	0.54 ± 0.04 *
Lean mass (kg)			
Total	58.64 ± 8.36 (43.93 - 74.90)	58.03 ± 7.52	59.43 ± 9.55 [n.s.]
Arm	7.21 ± 1.56 (4.66 - 10.48)	7.10 ± 1.57	7.37 ± 1.59 [n.s.]
Leg	20.49 ± 3.27 (14.72 - 28.24)	20.13 ± 2.80	20.95 ± 3.84 [n.s.]
Trunk	26.89 ± 4.43 (12.57 - 36.55)	27.05 ± 3.45	26.68 ± 5.59 [n.s.]
Spine	3.66 ± 0.33 (2.83 – 4.10)	3.75 ± 0.27	3.54 ± 0.37 [n.s.]

[1] Non – obese (body fat < 20%) and obese (body fat   20%).
[2] $L_1 – L_4$, $L_2 – L_4$ and 5 cm at L_4 regions were located between lumbar vertebral bodies upper L_1 and upper L_4, between lumbar vertebral bodies upper L_2 and upper L_4 and a rectangle of 5 cm of height at upper of lumbar vertebrae 4 and laterally to any trunk soft tissue.
[3] Mean ± SD (Minimum – Maximum).
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

Table 5 - Correlation coefficients among total, arm, leg, trunk and abdominal regions[1] fat percentage in obese and non-obese men [2]

	Arm	Leg	Trunk	Total 1[3]	Total 2[3]	C L_1L_4	T L_1L_4	C L_2L_4	T L_2L_4	C 5cm L_4	T 5cm L_4
Arm	-	0.85	0.95	0.95	0.94	0.90	0.91	0.88	0.90	0.88	0.90
Leg	0.78	-	0.89	0.96	0.97	0.80	0.81	0.78	0.79	0.82	0.85
Trunk	0.86	0.89	-	0.98	0.97	0.95	0.96	0.93	0.94	0.94	0.95
Total 1[3]	0.89	0.96	0.98	-	1.00	0.92	0.92	0.90	0.91	0.92	0.94
Total 2[3]	0.86	0.96	0.97	0.99	-	0.90	0.91	0.88	0.89	0.91	0.93
C L_1L_4	0.85	0.87	0.98	0.96	0.96	-	1.00	1.00	1.00	0.99	0.98
T L_1L_4	0.84	0.87	0.98	0.96	0.96	0.99	-	0.99	1.00	0.99	0.99
C L_2L_4	0.86	0.87	0.98	0.96	0.95	1.00	0.99	-	1.00	0.98	0.97
T L_2L_4	0.84	0.87	0.98	0.96	0.96	0.99	1.00	0.99	-	0.99	0.98
C 5cm L_4	0.86	0.88	0.96	0.95	0.95	0.99	0.97	0.99	0.97	-	1.00
T 5cm L_4	0.85	0.89	0.98	0.97	0.97	0.99	0.99	0.99	0.99	0.99	-

[1] L_1 – L_4, L_2 – L_4 and 5 cm at L_4 regions were located between lumbar vertebral bodies upper L_1 and upper L_4, between lumbar vertebral bodies upper L_2 and upper L_4 and a rectangle of 5 cm of height at upper of lumbar vertebrae 4 and laterally to any trunk soft tissue (T) or laterally as the continuation of the lateral sides of the rib cage (C).

[2] Non – obese (body fat < 20%) men, lower left and obese (body fat 20%) men, upper right.

[3] Total 1 is the body fat mass in relation to lean mass and total 2 is the body fat mass in relation to lean mass and bone mineral content together.

Table 6 – Skinfolds (mm) in youth men in the current and in another study.

Skinfolds	Current study			Another study[2]
	Non – obese[1] (n = 20)	Obese[1] (n = 15)	All (n=35)	
Triceps	8.6 ± 2.1 (5.0 – 12.3)[5]	15.5 ± 3.9 (10.7 – 25.2)**	11.5 ± 4.5 (5.0 - 25.2)	10.5 ± 4.8 (4.5 – 24.2)
Subscapular	9.5 ± 2.1 (7.0 – 13.7)	18.5 ± 6.3 (11.1 – 28.6) **	13.4 ± 6.3 (7.0 - 28.6)	10.6 ± 3.8 (5.4 – 21.5)
Biceps	4.2 ± 0.8 (3.2 – 6.2)	8.6 ± 3.5 (5.0 – 15.5) **	6.1 ± 3.2 (3.2 - 15.5)	4.7 ± 1.6 (2.7 – 10.1)
Midaxillary	7.3 ± 2.2 (4.7 – 12.5)	14.9 ± 6.1 (8.0 – 26.7) **	10.6 ± 5.7 (4.7 - 26.7)	10.2 ± 6.9 (3.8 – 33.5)
Iliac crest	11.8 ± 4.6 (6.4 – 23.0)	25.2 ± 7.7 (13.3 – 36.0) **	17.6 ± 9.0 (6.4 - 36.0)	12.9 ± 8.3 (4.1 – 41.0)
Supraspinale	8.6 ± 3.5 (4.4 – 19.4)	18.8 ± 8.0 (9.5 – 36.8) **	13.0 ± 7.7 (4.4 - 36.8)	8.3 ± 5.8 (2.8 – 30.5)
Abdominal	14.6 ± 5.8 (6.5 – 28.0)	26.9 ± 5.4 (18.6 – 36.5) **	19.9 ± 8.3 (6.5 - 36.5)	14.6 ± 9.0 (5.4 – 44.0)
Thigh	12.1 ± 4.2 (4.4 – 20.7)	24.7 ± 8.6 (13.3 – 38.5) **	17.5 ± 9.0 (4.4 - 38.5)	16.1 ± 8.2 (5.6 – 45.0)
Calf	7.4 ± 3.5 (3.5 – 14.0)	14.9 ± 4.1 (9.1 – 21.8) **	10.6 ± 4.9 (3.5 - 21.8)	9.4 ± 4.1 (4.1 – 19.8)
Chest	6.8 ± 2.5 (4 – 13.4)	12.4 ± 4.2 (6.9 – 21.8) **	9.2 ± 4.3 (4.0 - 21.8)	8.3 ± 4.8 (2.7 – 25.5)
Trunk[3]	35.0 ± 12.9 (18.4 – 66.4)	71.0 ± 18.5 (41.4 – 105.4) **	50.4 ± 23.7 (18.4 - 105.4)	-
Peripheral[4]	20.1 ± 4.7 (14.1 – 31.7)	38.9 ± 10.1 (26.5 – 62.2) **	28.2 ± 12.0 (14.1- 62.2)	-

[1] Non – obese (body fat < 20%) and obese (body fat 20%). [2] Data from 32 men aged 17-18 years with body mass index ranging from 16.3 to 30.7 $kg.m^{-2}$ (Lintsi *et al.*, 2004). [3] Trunk is the sum of subscapular, supraspinale and abdominal. [4] Peripheral is the sum of calf, biceps and triceps. [5] Mean ± SD (Minimum – Maximum). [n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

Table 7 –Blood lipid levels in men in the current study and others

	Current study			**Other studies**		
	Non - obese[1] (n = 21)	**Obese[1] (n = 17)**	**All**	**A [2]**	**B [3]**	**C [4]**
TC[5]	4.29 ± 0.91 (2.60 – 6.60) [6]	4.66 ± 1.0 (3.20 – 7.50) [n.s.]	4.46 ± 0.96	4.92 ± 1	5.81 ± 0.97	4.84 ± 0.22
HDL-C[5]	1.45 ± 0.29 (0.79 – 2.01)	1.26 ± 0.21 (0.70 – 1.66) *	1.37 ± 0.27	1.16 ± 0.3	0.96 ± 0.19	0.77 ± 0.04
LDL-C[5]	2.55 ± 0.82 (1.04 – 4.58)	2.82 ± 0.72 (1.01 – 3.96) [n.s.]	2.67 ± 0.78	2.80 ± 1	4.01 ± 0.84	-
Triglycerides	0.85 ± 0.29 (0.50 – 1.7)	1.44 ± 1.40 (0.50 – 6.50) *	1.11 ± 0.99	1.66 ± 0.05	1.86 ± 0.71	2.35 ± 0.59
TC/HDL-C	3.04 ± 0.78 (1.84 – 5.06)	3.85 ± 1.21 (1.93 – 7.14) *	3.40 ± 1.06	-	-	-
LDL-C/HDL-C	0.64 ± 0.31 (0.39 – 1.92)	0.60 ± 0.09 (0.32 – 0.69)*	0.62 ± 0.23	-	-	-

[1] Non – obese (body fat < 20%) and obese (body fat 20%).
[2] Study A = Data from 904 men aged 25 to 64y (Singh *et al.*, 1998).
[3] Study B = Data from 46 obese men, with BMI between 28 and 38 $kg.m^{-2}$, aged 25 to 51y (van der Kooy *et al.*, 1993).
[4] Study C = Data from 18 overweight and obese men, with BMI of 30.9 ± 0.7 $kg.m^{-2}$, aged 37.4 ± 1.3y (Gan *et al.*, 2003).
[5] TC = Total Cholesterol, HDL-C = High-density lipoprotein cholesterol and LDL-C = Low-density lipoprotein cholesterol.
[6] Mean ± SD (Minimum – Maximum).
[n.s.] $P > 0.05$, * $P < 0.05$ and ** $P < 0.01$ for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

Table 8 – Prevalence of men (%) above target blood lipid levels in the current study and in others

Lipids	Current study				Other studies	
	Criteria	Non - obese[1] (n = 21)	Obese[1] (n = 17)	All	A [2]	B [3]
TC (mmol.L^{-1}) [4]	> 4.0	61.9	76.5	68	33 (> 5.18) [5]	26.4 (4.40) [5]
LDL- C (mmol.L^{-1}) [4]	> 2.5	48	76.5	65.8	31 (> 3.21)	26.9 (2.59)
HDL- C (mmol.L^{-1}) [4]	< 1.0	5	11.8	8	12 (< 0.9)	81.3 (< 1.17)
Triglycerides (mmol.L^{-1})	> 2.0	0	11.8	5	21 (> 2.08)	13.4 (1.13)

[1] Non – obese (body fat < 20%) and obese (body fat   20%).
[2] Data from 904 men aged 25 to 64y (Singh *et al.*, 1998).
[3] Data from 300 male adolescents aged 14 to 16y (Kuzawa *et al.*, 2003).
[4] TC = Total Cholesterol, HDL-C = High-density lipoprotein cholesterol and LDL-C = Low-density lipoprotein cholesterol.
[5] Percentage of men above target lipid levels (criteria used in studies).

Table 9 – Reported food intake in young men in the current and another study

	Current study			Survey [2]
	Non-obese[1] (n = 20)	Obese[1] (n = 16)	All	
Energy (kcal)	2681 ± 537 (1876 - 3713)[5]	2702 ± 611 (1712 - 3639) [n.s.]	2725 ± 559	3172.92
Protein (g)	108.8 ± 27.1 (60.7 - 163.6)	118.9 ± 37.4 (46.3 - 180.9) [n.s.]	113.3 ± 32.0 (16.9) [6]	127.7 (16.6) [6]
Fat (g)	96.0 ± 19.4 (62.7 - 130.2)	96.0 ± 26.5 (47.9 - 139.6) [n.s.]	96.0±22.4 (32.3)	119.1 (32.9)
Saturated (g)	39.3 ± 11.2 (19.4 - 57.1)	38.0 ± 14.0 (14.7 - 61.0) [n.s.]	38.7 ± 12.4 (12.8)	48.4 (13.3)
PUFA[3] (g)	13.2 ± 2.6 (8.6 - 18.9)	13.6 ± 3.6 (7.2 - 21.7) [n.s.]	13.4 ± 3.1 (4.5)	17.0 (4.7)
MUFA[4] (g)	35.3 ± 6.8 (24.6 - 46.3)	36.2 ± 9.9 (19.8 - 51.0) [n.s.]	35.7 ± 8.2 (11.9)	43.9 (12.1)
Cholesterol (mg)	367.1 ± 143.5 (106.7 - 635.6)	331.2 ± 178.3 (57.0 - 677.4) [n.s.]	351.2 ± 158.5	416.5
Carbohydrate (g)	314.7 ± 60.2 (193.4 - 467.6)	326.9 ± 101.4 (180.9 - 545.2) [n.s.]	320.1 ± 80.1 (47.7)	375.9 (46.9)
Fibre (g)	27.3 ± 10.4 (12.2 – 51.7)	23.8 ± 5.6 (13.6 - 35.3) [n.s.]	25.8 ± 8.7	26.2
Alcohol (g)	17.5 ± 22.3	7.9 ± 19.7 (0 - 77.4) [n.s.]	13.2 ± 21.4 (3.1)	15.2 (3.6)

[1] Non – obese (body fat < 20%) and obese (body fat 20%). [2] Data from 866 Australian men aged 19 to 24 y (McLennan and Podger, 1995).
[3] Polyunsaturated fatty acids. [4] Monounsaturated fatty acids. [5] Mean ± SD (Minimum – Maximum). [6] Mean ± SD (relative value to EI).
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for comparison between obese and non-obese groups using two-tailed Student t-test for group means.

Table 10 – Vitamin and mineral intake in young men in the current study and others

Nutrients	**Current study**			**Survey**[1]	**RDI**[2]	**UL**[3]
	All	**Non-obese (n = 20)**	**Obese (n = 16)**			
Thiamin (mg)	2.4 ± 1.5 (0.8 – 7.9) [4]	2.0 ± 0.7	2.8 ± 2.1 [n.s.]	2.3	1.1	-
Riboflavin (mg)	2.8 ± 1.4 (0.9 – 6.9)	2.6 ± 1.0	3.1 ± 1.6 [n.s.]	2.7	1.7	-
Niacin Eq (mg)	51.1 ± 12.9 (22.9 – 76.3)	49.3 ± 12.2	53.3 ± 13.8 [n.s.]	57.6	19	35
Vitamin C (mg)	144.0 ± 81.5 (24.0 – 350.)	149.0 ± 84.8	137.8 ± 79.5 [n.s.]	149.6	40	2000
Folate (mcg)	350.7 ± 123.3 (156.2 – 687.0)	379.6 ± 138.2	314.5 ± 93.7 [n.s.]	321.8	200	1000
Vit A Eq (mcg)	976.8 ± 403.4 (499.8 – 1933.7)	941.2 ± 386.2	1021.3 ± 432.4 [n.s.]	1233.4	750	3000
Potassium (mg)	3606.5 ± 1077.4 (1786.5 – 7637)	3546.7 ± 1234.7	3681.3 ± 875.7 [n.s.]	3943.0	1950	5460[5]
Magnesium (mg)	372.1 ± 107.3 (213.48 – 670.5)	374.7 ± 112.5	368.9 ± 104.0 [n.s.]	390.1	320	350[6]
Calcium (mg)	1130.0 ± 467.5 (417.2 – 2194)	1057.2 ± 333.1	1221.0 ± 594.7 [n.s.]	1101.1	800	2500
Phosphorus (mg)	1881.1 ± 508.7 (827.5 – 2763.7)	1853.1 ± 464.8	1916.2 ± 572.5 [n.s.]	2051.5	1000	4000
Iron (mg)	15.2 ± 4.4 (8.8 – 27.7)	16.2 ± 5.0	14.0 ± 3.4 [n.s.]	17.9	7	45
Zinc (mg)	14.4 ± 4.7 (6.8 – 29.1)	13.4 ± 4.5	15.6 ± 4.8 [n.s.]	17.3	12	40

[1] Data 866 men aged 19 to 24 y (McLennan and Podger, 1995). [2] Recommended Dietary Intakes for adults for use in Australia (NHMRC, 1991).
[3] Upper limits (Yates *et al.*, 1998). [4] Mean ± SD (minimum – maximum). [5] Upper limit for adults for use in Australia (NHMRC, 1991).
[6] UL for magnesium represent intake from a pharmacological agent only and do not include intake from food and water.
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for comparison between obese and non-obese groups using two-tailed Student t-test for group means.

Table 11 - Resting metabolic rate (RMR), respiratory exchange ratio (RER), daily energy expenditure (EE) (kcal/day), physical activity energy expenditure (PAEE) (kcal/day) and physical activity level (PAL) in young men

	All	**Non- obese[1]**	**Obese[1]**
RMR	1916.4 ± 325.2 (1348.9 – 2967.9) [5]	1837.9 ± 277.0	2013.4 ± 361.3 $^{n.s.}$
RER (CO_2/O_2)	0.79 ± 0.06 (0.63 – 0.88)	0.80 ± 0.07	0.78 ± 0.06 $^{n.s.}$
EE			
Weekday 1	3573.1 ± 843.3 (2176.8 – 6004.4)	3489.8 ± 636.2	3676.0 ± 1057.6 $^{n.s.}$
Weekday 2	3434.5 ± 823.4 (1999.2 – 5267.3)	3387.2 ± 842.7	3493.0 ± 820.6 $^{n.s.}$
Saturday	3842.0 ± 921.8 (1983.5 – 5750.2)	3856.3 ± 1006.2	3824.3 ± 835.8 $^{n.s.}$
Sunday	3563.5 ± 738.5 (2158.7 – 5623.5)	3510.1 ± 632.2	3629.4 ± 868.0 $^{n.s.}$
Mean[2]	3603.3 ± 704.5 (2213.4 – 5396.3)	3560.8 ± 649.2	3655.7 ± 784.7 $^{n.s.}$
EE / BMI[3]	143.9 ± 26.0 (93.2 – 201.0)	154.9 ± 22.9	130.3 ± 23.6 *
PAEE (EE – RMR)	1686.9 ± 453.8 (632.7 – 2513.6)	1723.0 ± 425.3	1642.3 ± 496.3 $^{n.s.}$
PAEE / BW[4]	21.9 ± 6.3 (8.7 – 35.0)	24.5 ± 5.6	18.6 ± 5.7 **
PAEE / RMR	0.88 ± 0.19 (0.40 – 1.26)	0.94 ± 0.16	0.81 ± 0.21 $^{n.s.}$
PAL			
Weekday 1	1.86 ± 0.28 (1.38 - 2.50)	1.90 ± 0.23	1.81 ± 0.33 $^{n.s.}$
Weekday 2	1.79 ± 0.26 (1.37 - 2.47)	1.83 ± 0.28	1.73 ± 0.24 $^{n.s.}$
Saturday	2.01 ± 0.38 (1.45 - 3.12)	2.09 ± 0.41	1.91 ± 0.32 $^{n.s.}$
Sunday	1.87 ± 0.29 (1.37 - 2.57)	1.92 ± 0.28	1.80 ± 0.31 $^{n.s.}$
Mean[2]	1.88 ± 0.19 (1.40 – 2.26)	1.94 ± 0.16	1.81 ± 0.21 $^{n.s.}$

[1] Non – obese (body fat < 20%) and obese (body fat 20%).
[2] Mean of 4 days (2 weekdays, Saturday and Sunday) estimated from PA records.
[3] EE / BMI = mean energy expenditure of 4 days (kcal) divided by body mass index ($kg.m^{-2}$).
[4] PAEE / BW = physical activity energy expenditure (kcal) divided by body weight (kg).
[4] Mean ± SD (minimum – maximum).
$^{n.s.}$ P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

Table 12 - Time (min) spent in light, moderate and intense physical activity by young men

Physical Activity Level	**All**	**Non-obese [1] (n = 21)**	**Obese [1] (n = 17)**
Light (< 3MET[2])	1298.5 ± 72.9 (1136.3 - 1425.0) [3]	1276.3 ± 67.8	1326.0 ± 71.4 *
Moderate (3 MET < 6)	102.5 ± 78.9 (0 – 292.5)	120.0 ± 82.4	81.0 ± 70.8 [n.s.]
Intense (6MET)	37.9 ± 32.2 (0 – 116.3)	42.0 ± 30.8	32.9 ± 34.2 [n.s.]
Moderate + Intense	140.4 ± 74.3 (15 – 303.8)	162.0 ± 70.8	113.8 ± 71.7 *

[1] Non – obese = body fat < 20% (number of participants) and obese = body fat   20%.
[2] MET = metabolic equivalents = Energy expenditure / resting metabolic rate.
[3] Mean ± SD (Minimum - Maximum).
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

Table 13 – Mean time (min) spent on physical activities by young men

Physical activities[1]	**MET**[2]	**All**	**Non obese**[3] **(n = 21)**	**Obese**[3] **(n = 17)**
Sleeping	1	504.2 ± 67.1 (367.5 ± 663.8) [4]	492.7 ± 62.7 (34.3%)[5]	518.4 ± 71.4 (36.0%) [n.s.]
Siting	1.5	435.1 ± 158.0 (131.3 ± 753.8)	404.8 ± 142.5 (28.2%)	472.5 ± 172.3 (32.9%) [n.s.]
Standing	2.3	197.2 ± 122.6 (0.0 ± 690.0)	223. ± 124 (15.6%)	164.1 ± 115.7 (11.4%) [n.s.]
Walking less than 4 $km.h^{-1}$	2.8	162.0 ± 96.1 (15.0 ± 420.0)	154.8 ± 100.5 (10.8%)	171.0 ± 92.7 (11.9%) [n.s.]
Walking at 4 to 6 $km.h^{-1}$	3.3	77.4 ± 67.2 (0.0 ± 210.0)	90.9 ± 68.9 (6.3%)	60.7 ± 63.1 (4.2%) [n.s.]
Cycling less than 10 $km.h^{-1}$	4.8	14.4 ± 20.0 (0.0 ± 75.0)	16.6 ± 21.0 (1.2%)	11.7 ± 19.0 (0.8%) [n.s.]
Loading and unloading	5.6	10.8 ± 22.8 (0.0 ± 101.3	12.5 ± 24.1 (0.9%)	8.6 ± 21.5 (0.6%) [n.s.]
Cycling more than 15 $km.h^{-1}$	6.0	20.1 ± 27.4 (0.0 ± 116.3)	21.4 ± 23.2 (1.5%)	18.5 ± 32.5 (1.3%) [n.s.]
Mountain climbing	7.8	17.8 ± 19.8 (0.0 ± 60.0)	20.5 ± 20.0 (1.4%)	14.3 ± 19.7 (1.0%) [n.s.]

[1] Some examples of physical activities performed by the participants.
[2] MET: metabolic equivalents = EE / RMR.
[3] Non – obese (body fat < 20%) and obese (body fat   20%).
[4] Mean ± SD (Minimum - Maximum).
[5] Mean ± SD (percentage of time spent in each physical activity level).
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

Table 14 – Resting heart rate (HR) [1], time (min), respiratory exchange ratio (RER), maximum HR, oxygen consumption maximum (VO_{2max}) and Borg scale score during cardiorespiratory fitness test in young men.

	All (n = 32)	**Non-obese[2] (n = 19)**	**Obese[2] (n = 13)**
Resting HR	62.6 ± 9.6 (41 – 86) [3]	62.7 ± 11.5	62.5 ± 6.0 [n.s.]
Time	11.06 ± 1.41 (7 - 14)	11.79 ± 1.08	10.00 ± 1.15 **
RER	1.21 ± 0.09 (1.01 – 1.54)	1.20 ± 0.08	1.23 ± 0.11 [n.s.]
HR_{max}	190.34 ± 8.15 (174 – 204)	190.37 ± 9.49	190.31 ± 6.03 [n.s.]
VO_{2max}	51.17 ± 8.71 (25.16 – 67.78)	55.62 ± 5.88	44.67 ± 8.19 **
Borg	18.81 ± 1.25 (16 – 20)	18.95 ± 1.22	18.58 ± 1.31 [n.s.]

[1] Resting heart rate assessed before to start the cardiorespiratory fitness test.
[2] Non – obese (body fat < 20%) and obese (body fat 20%).
[3] Mean ± SD (Minimum - Maximum).
[n.s.] P > 0.05, * P < 0.05 and ** P < 0.01 for the comparison between obese and non-obese groups using a two-tailed Student t-test for group means.

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CONCLUSION

On the first study, two methods of measuring physical activity were compared in 11 young men. The energy expenditure (EE) was overestimated by Bouchard physical activity record (B-PAR) in 14.7% in relation to RT3. The physical activity records limitations and the lack of participants' commitment contribute to EE overestimated by B-PAR in relation to RT3. Recording PA while wearing accelerometer allowed us realize that the participants took off the accelerometer in most of the time for doing intense PA.

On the second study, two methods of measuring food intake were compared in 34 young men: 24-hour dietary recall method (24hDR) and 4-day food record (4dFR). There were good agreement between the measurements of energy and macronutrients intake by 24hDR and 4dFR at the group level, but not at the individual level. Compared to EE assessed by B-PAR, it was possible to assess underreporting in youth men and to evaluate the accuracy of the Goldberg cut-off method for identifying underreporting. At the group level, obese (body fat   20%) and non-obese (body fat < 20%) groups underreported EI by both 4dFR and 24hDR methods. At the individual level, 20.6% and 8.8% of participants underreported their EI by 4dFR and 24hDR, respectively considering the 95% confidence interval for EI / EE criteria. The sensitivity and specificity of Goldberg cut-off method were 0.86 and 0.93, respectively for 4dFR. For 24hDR, the corresponding values were 1.00 and 0.90, respectively. There was no difference significant in macronutrients intake expressed in energy percentage and in micronutrients between under-reporters and acceptable reports suggesting that the diet data can be used in analysis with other variables in the evaluation of the relation between diet and health, since macronutrients are expressed in energy values.

On the last study, body composition, resting metabolic rate, blood lipid pattern, food intake, physical activity pattern and cardiovascular fitness were assessed in 38 young men. From the participants of the current study, 10.5% were classified as underweight (body mass index, BMC < 20 kg.m^{-2}), 47.4% as healthy range (20 BMC 24.9 kg.m^{-2}), 31.6% as overweight (25 BMC 29.9 kg.m^{-2}) and 10.5% as obese (BMC 30 kg.m^{-2}). When assessed by DEXA, the body fat of participants of the current study ranged from 6.0 to 37.0%. Obese and non-obese men had similar fat free mass and bone mineral content. More than 70% of bone mineral content and more than 80% of fat free mass are on leg and trunk together. The RMR of obese men was similar to those of non-obese had likely due to similar amount of fat free mass.

The mean intake of fat and carbohydrate of the participants of the current study were above (32.3%) and below (47.1%), respectively, to the recommendation (30% and 50%, respectively). The mean polyunsaturated fatty acids (13.4 g.d^{-1}) and fiber intake (25.8 g.d^{-1}) were lower than the recommended value (18.6 g.d^{-1} and 38 g.d^{-1}, respectively). The intake of almost all vitamins and minerals was between recommendation (RDI) and the upper limit (UL). Only the niacin intake was above the UL (35 mg.d^{-1}).

An overall, the mean time spent in moderate and intense activity, was 140.4 min. Obese (body fat 20%) spent more time doing moderate and intense physical activity than non obese (body fat < 20%) men. However, to some participants who are not spending the recommended minimum time, more physical activity of moderate and or intense level should be recommended. The level of fitness was excellent for non-obese men (55 ml.kg^{-1}.min^{-1}) and at average for obese (44 ml.kg^{-1}.min^{-1}) compared with values published by American College of Sports Medicine (>51 ml.kg^{-1}.min^{-1} and of 42 to 48 ml.kg^{-1}.min^{-1}, respectively).

Increasing PA and having a healthy and well balanced diet may help to increase fat free mass which increase resting metabolic rate (RMR). A higher RMR accounts for a higher EE, which would account for an imbalance between EI and EE in order to lost weight and therefore to decrease the obesity. Besides to contribute to decrease obesity, increased physical activity and healthy diet may also be contributing to improve the blood lipid pattern, as 68% of the participants had total cholesterol above the recommended limits (4.0 mmol.L^{-1}). Combined measurements can result in greater help than isolated measurements.

APPENDIX 1

HUMAN RESEARCH ETHICS DOCUMENT

QUT
Queensland University of Technology Gardens Point Campus
2 George Street GPO Box 2434 Brisbane Qld 4001 Australia
Phone 07 3864 2111 Fax 07 3864 1510 www.qut.edu.au
CRICOS No. 00213J ABN 83 791 724 622

30 June 2004

Prof Andrew Hills
School of Human Movement Studies
A Block
QUT
Kelvin Grove Campus

Dear Andrew

I write further to the minor changes requested for your projects, "Effectiveness of personalised polar weight management concept" (QUT Ref No 2904H) and "Exercise modalities for mobility-impaired adults: A collaborative weight-loss project for the overweight" (QUT Ref No 2905H).

The Chair, University Human Research Ethics Committee (UHREC), has considered these minor changes and requested I respond on her behalf. The Chair has approved, under executive powers, the minor changes to this project. Consequently, approval is provided for:

- an additional subject group (males and females) aged from 18-25 years;
- an additional test protocol that involves the collection of 9 skinfold sites; and
- the additional subjects and test protocol to be used as part of Ms Selma Liberato's PhD thesis.

This decision is subject to ratification at the 27 July 2004 meeting of UHREC. I will only contact you again in relation to this matter if the Committee raises any additional questions or concerns in regard to the minor changes.

Please do not hesitate to contact me further if you have any queries regarding this matter.

Yours sincerely

W. Heffernan

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APPENDIX 2

Bouchard Physical Activity Record (B-PAR)

PHYSICAL ACTIVITY RECORD

Name:	
Date:	Week day:

Hour	Minutes				
	00 - 15	16 - 30	31 - 45	46 - 60	Obs.
00					
01					
02					
03					
04					
05					
06					
07					
08					
09					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					

Write in the space provided the categorical value which corresponds best to the dominant activity of each 15-minute period. Please, consult the activity card to establish the proper coding. In case of doubt, make a note and raise the problem during the interview.

Categorical value	Examples of activities	Median energy cost (kcal/kg/15 min)
1	Sleeping, resting in bed	0.26
2	Sitting: eating, listening, writing, etc	0.38
3	Light activity standing: washing, shaving, combing, cooking, etc	0.57
4	Slow walk (< 4 km/h), driving, to dress, to shower	0.69
5	Light manual work: floor sweeping, window washing, driving a truck, painting, waiting on tables, nursing chores, several house chores, electrician, barman, walking at 4 to 6 km/h	0.84
6	Leisure activities and sports in a recreational environment: baseball, golf, volleyball, canoeing or rowing, archery, bowling, cycling (< 10 km/h), table tennis, etc	1.2
7	Manual work at moderate pace: mining, carpentry, house building, lumbering and wood cutting, snow shovelling, loading and unloading goods, etc	1.4
8	Leisure and sport activities of higher intensity (not competitive): canoeing (5 to 8 km/h), bicycling (> 15 km/h), dancing, skiing, badminton, gymnastic, swimming, tennis, horse riding, walking (> 6 km/h)	1.5
9	Intense manual work, high intensity sport activities or sport competition: tree cutting, carrying heavy loads, jogging and running (> 9 km/h), racquetball, swimming, tennis, cross country skiing (> 8 Km/h), hiking and mountain climbing, etc	2.0