Body composition changes in an endurance athlete using two different training strategies.

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Abstract

Swimming, running and cycling are among the most popular and fastest growing sports in the world. Inherent in these sports is a desire to favourably alter body composition. Here we report a ~5.4kg and ~5.3kg fat tissue mass (FTM) loss in two separate interventions (12 – 16 weeks), in the same athlete, separated by 5 years. Whole body composition was assessed using dual x-ray absorptiometry (DXA). Dietary analysis for intervention 2 was completed using Mc Cance and Widdowson’s composition of foods. In 2010, the male athlete (23 yrs, 85kg, 195cm, 18.1% body fat (BF)) had a reduction of ~5.4kg of FTM (15.4kg *vs.* 10.0kg) and an increase of ~5.1kg of lean tissue mass (LTM) following 16 weeks of moderate intensity running (213 (53) min/week) and circuit training (64 (46) min/week). In 2015, the same athlete (28 yrs, 90.6kg, 195cm; 18.2%) had a ~5.3kg loss of FTM and a ~0.8kg increase in LTM after 12 weeks, predominately (75%) non-weight bearing exercise (49% Cycling, 215 (88) min/week; 25% Running 110 (47) min/week; 19% Swimming, 83 (27) min/week; 7% Rowing Machine, 29 (26) min/week). Weekday and weekend dietary intake during intervention 2 were estimated as 2,560 kcal and 3,240 kcal per day respectively. This report provides support for the hypothesis that an extended period of energy deficit is required to reduce body fat levels in amateur athletes independent of the mode of exercise.

Key words: fat mass, DXA, exercise, running, swimming, cycling

Introduction

Swimming, running and cycling are among the top 6 most popular and fastest growing sports in the world for 2014 (Sport England, 2015; Sports and Fitness Industry Association, 2015). Inherent in weight sensitive endurance sports is a desire to favourably alter body composition for performance (Sundgot-Borgen et al., 2013). Increasingly, amateur athletes are aware of studies reported by the media as to the most appropriate exercise and/or dietary strategy to reduce fat tissue mass (FTM) whilst maintaining lean tissue mass (LTM). This information has made been made more easily accessible by the rise in social media use over the past 10 years (Gironda and Korgaonkar, 2014). In February of this year, exercise was proclaimed as ‘a miracle cure’ by the UK’s Academy of Medical Royal Colleges whilst in May, the headline of an editorial in the British Journal of Sports Medicine (Malhotra et al., 2015) suggested ‘you cannot outrun a bad diet’, a story largely publicised by the British Broadcasting Corporation (BBC, 2015). There is evidence to support the use of aerobic training over resistance training for greater FTM loss (Willis et al., 2012). Conversely, there is evidence to support the use of resistance training over aerobic training for greater FTM loss (Mekary et al., 2015). Recently, high intensity interval training (HIIT) has been proposed as an effective strategy to reduce FTM (Hazell et al., 2014). Despite what may appear as conflicting evidence in the literature, a consistent period of energy deficit in order to reduce FTM has been consistently summarised in the literature (Speakman et al., 2011, Hall et al., 2012, Thompson et al., 2012).

Case Report

This case report presents 7 years (2008 – 2015) of body composition data (Table 1) of a former male amateur runner (2004 – 2013; 5k: 16m 10s, 10k: 34m 40s) and current amateur triathlete (2014 – 2015; Half-Iron Distance: 5hr 32m). The report focuses on two time points in which 12 – 16 weeks training data (Table 2) was recorded in a training diary between body composition assessments (Table 1). Body composition was assessed using Dual X-Ray Absorptiometry (iDXA^{TM}; GE Healthcare, Chalfont St Giles, Bucks., UK) in accordance with procedures used for the University of Limerick Body Composition Study (ULBC) outlined in Leahy et al. (2013) and approved the research ethics committee (EHS-REC 09-18). The participant provided written informed consent for this data to be reported.

To provide an estimate of comparative workloads for both interventions, we calculated the metabolic equivalent of task (MET) for the various modes of exercise undertaken in both interventions. An MET is a measure of the energy cost of activities and is defined as the ratio of metabolic rate to a resting metabolic rate of 1.0 (4.184 $kJ\cdot kg^{-1}\cdot h^{-1}$). Ainsworth et al. (2000) have provided MET's for activities ranging from sleeping (0.9 METs) to running at 10.9 mph (18 METs) which we have used to report the energy cost of the interventions in the present report (Table 3). Dietary intake was not recorded before or during the intervention, therefore we retrospectively asked the athlete to comment on a typical week and weekend day of his dietary intake (Table 4). Dietary intake was analysed using McCance and Widdowson's, The Composition of Foods, 7th Edititon. The athlete described his weekday intake as more predictable due to the routine of work and training. The athlete reported his core dietary intake to remain similar during non-intervention periods but did report making a more conscious effort during intervention periods to adopt healthier dietary habits such as the reduction of sugar and alcohol intake.

Intervention 1: The athlete (23 yrs, 85kg, 195cm, 18.1% body fat (BF)), a research student, reported for body composition assessment on the 30th June, 2010. Prior to this point, the athlete had not been engaged in regular run training for a period of 1 year due to travelling abroad. The athlete did report remaining recreationally active (40 – 50 min; 3 – 4 days p/week). The main change in body composition that had occurred compared with the athletes previous body compositional assessment (10/11/2008) was an increase in FTM (15.4kg *vs.* 11.1kg), LTM remained relatively unchanged and within the measurement error of DXA (65.9kg *vs.* 66.1kg). Subsequently, the athlete engaged in 16 weeks of run (~3.6 hours per week; ~43 minutes per day; ~7.5 minutes per mile) and circuit (~1hr per week) training. Re-assessment after 16 weeks revealed a ~5.1kg increase in LTM and a ~5.4kg reduction in FTM.

Intervention 2: The athlete (28 yrs, 90.6kg, 195cm; 18.2% BF), a lecturer, reported for body composition assessment on the 3rd of April, 2015. Prior to this point the athlete was not in a formal training routine for a period of 12 months but was recreationally active (40 – 50 minutes; 5 – 6 days p/week). The main change in the intervening 5 years between intervention 1 and 2 was an increase in FTM (16.5kg *vs.* 10.0kg). LTM remained relatively constant (70.5kg *vs.* 71.0kg) as outlined by the mean LTM (71 (0.9) kg) from 7 scans taken during the period 2010 - 2014. Subsequently, the athlete engaged in a 12 week, predominately (75%) non-weight bearing, training regime (49% cycling, 25% running, 19% swimming, 7% rowing) for ~7.3 hours per week. A representation of typical dietary intake (Table 4) and macronutrient composition (Table

5) during the intervention period are provided. Re-assessment after 12 weeks revealed a ~0.8kg increase in LTM and a ~5.3kg reduction in FTM.

Discussion

We report a ~5kg FTM loss in two separate interventions of 16 and 12 weeks duration, in the same athlete separated by 5 years. Intervention 1 was entirely weight bearing and contained a mixture of aerobic (70%) and resistance (30%) training. Intervention 2 was predominately non-weight bearing (75%) and did not contain any resistance training. This case study demonstrates that an athlete who induces an energy deficit for a consistent period (12 – 16 weeks) can demonstrate a significant reduction in FTM. Furthermore, this case report agrees with existing evidence which suggests when exercise is used to induce part of the energy deficit, LTM can be maintained or increased which would not be the case with caloric restriction alone (Racette et al., 2006).

A commonly used energy density for fat is 9kcal per gram (Widdowson, 1955). A ~5kg reduction in FTM constitutes an energy total of ~45,000 kcal which is within the estimated kcal (~79,000 – 84,000) required to perform the training load in intervention 1 and 2. An unexpected finding from intervention 1 was the accompanying ~5kg increase in LTM which represents a change that might be expected from that of a resistance training programme (4 – 6 sets, 8 – 15 repetitions, 3 – 5 d/week) designed to induce hypertrophy (Bird et al., 2005). One possible explanation is that the athlete body mass at the beginning of intervention 1 was ~5kg more than it had been previously when undergoing formal run training. It may be that an increase in LTM was required to support a new body mass undertaking formal run and circuit training. Furthermore, as the athlete was 23 years old at the beginning of intervention 1, there may have been some developmental changes occurring concurrently. Previously, Silva et al. (2010) reported skeletal mass and age to remain positively correlated up until age ~27 years in men. Whilst these are plausible explanations, the observed increase in LTM (~0.8kg) during intervention 2 suggests it is possible to accrue LTM during a period of extended energy deficit induced by non-weight bearing exercise. It must be acknowledged that we did not have control over the dietary intake in either intervention. The estimated protein intake (1.6 – 1.7 $\cdot kg^{-1}$ $BW \cdot day^{-1}$) is above the recommended daily allowance (RDA; $0.8 \cdot kg^{-1}$ $BW \cdot day^{-1}$), at the higher end of the amount (1.2 – 1.6 $\cdot kg^{-1}$ $BW \cdot day^{-1}$) recommended for endurance athletes (Phillips, 2012) but within the range (1.3 – 1.8 $\cdot kg^{-1}$ $BW \cdot day^{-1}$) suggested to be able to offset LTM losses during a period of energy deficit (Phillips, 2014).

We did not have control over the precise energy intake or exercise intensities used to elicit the FTM changes in this report. However, the physiology which underpins the predominate mode of exercise in the current interventions is well established and may shed some light on the body composition changes seen. Moderate intensity exercise causes a profound increase in fatty oxidation up to 60 – 65% VO_2max (Romijn et al., 1993). Furthermore, exercise induces an increase in 24 hour fat oxidation (Melanson et al., 2002) which may be the basis for the energy deficit, as fat is diverted towards muscle rather than adipose tissue. If exercising every day, as was almost the case in both interventions, an individual spends much of their time in a post exercise state. This cannot be achieved by calorie restriction alone. There is some evidence to suggest that the adaptation to endurance training such as increased capillary angiogenesis and mitochondrial biogenesis (Holloszy and Coyle, 1984) may allow for increases in fat oxidation during activities of everyday living (Thompson et al., 2012). Finally, fasted exercise, which took place on the weekend in both interventions, has been shown to increase fat oxidation compared to when in the post-prandial state (Horowitz et al., 1997).

Using the MET for various activities as reported by Ainsworth et al. (2000), we estimated the total workload (kcal) for both interventions and found only a ~5% difference, which may help to explain the similar FTM loss. However, it is important to recognise that weekly training time in the second intervention which was predominately non-weight bearing was 36% greater than that of intervention 1 which was exclusively weight bearing. This may be a consideration for athletes wishing to lower FTM in a pre-determined time frame. Conversely, a non-weight bearing strategy to lower FTM may also be useful for the athlete who must also manage weight bearing activity around musculoskeletal injury risk as was the case in this case report. Fat mass is a representation of energy balance over an extended period of time, in fact, daily differences in energy intake and expenditure may be as little as 38 KJ (Speakman et al., 2011). Key to fat mass losses will be the maintenance of physical activity in everyday living so that additional exercise to induce energy deficit was not compensated for by reduced physical activity.

Conclusion

This case report highlights that independent of the mode of exercise, it is possible for an amateur athlete to reduce FTM whilst maintaining or improving LTM. This can be achieved whilst maintaining a balanced diet and reducing sugar and alcohol intake. To reduce FTM an extended period of energy deficit is required. In the case of this athlete, there appears to be a lower time cost to reducing FTM when using weight bearing compared to non-weight bearing exercise, most likely due to the higher metabolic equivalent of task associated with weight bearing activities.

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Title of Tables

5. Table 5: Energy intake and percentage macro-nutrient composition on week and weekend days.

Titles of Figures

1. Figure 1: Progressive weekly training load for intervention 1 (orange) and 2 (blue).

Table 1: Body composition data for an endurance athlete between 2008 – 2015.

Time Point	Body Mass (kg)	Lean Tissue Mass (kg)	Body Fat Mass (kg)	Body Fat (%)
		Pre-Interventions		
10/11/2008	80.7	66.1	11.1	13.7
		Intervention 1		
Week 0 30/06/2010	85.0	65.9	15.4	18.1
Week 16 28/10/2010	86.2	71.0	10.0	12.5
	Between Intervention Summary (Mean of n= 12DXA scans)			
2011 - 2014	88.6 (1.6)	71.0 (0.9)	13.8 (2.0)	15.6 (2.0)
		Intervention 2		
Week 0 03/04/2015	90.6	70.4	16.5	18.2
Week 12 18/06/2015	86.2	71.2	11.2	13.0

Values are reported as mean (standard deviation).

Table 2: Weekly training data for intervention 1 and 2.

	Run	Circuit	Bike	Swim	Row	Total
			Intervention 1			
Mean (SD)	213 (53)	64 (46)				277 (88)
Median (IQR)	210 (94)	60 (105)				270 (126)
Min - Max	109 - 290	0 - 120				109 - 403
			Intervention 2			
Mean (SD)	110 (47)		215 (88)	83 (27)	29 (26)	437 (94)
Median (IQR)	100 (80)		240 (90)	80 (40)	40 (40)	476 (143)
Min - Max	47 - 210		60 - 340	40 - 120	0 - 80	270 - 552

Values reported as mean (standard deviation), median (inter-quartile range) and min-max.

Table 3: Estimated energy required to complete intervention 1 and 2.

Resting kcal/min (BM*1kcal*hr)/60	Activity	Activity MET	Activity kcal/min	Activity Minutes	Estimated Total Kcal
			Intervention 1		
1.42	Running (7min-mile)	14.0	19.9	3415	67885
	Circuits	8.0	11.4	1020	11587
Estimated Total					**79472**
			Intervention 2		
1.51	Running (7.5 min-mile)	13.5	20.4	1282	26134
	Cycling (14 – 15.9 mph)	10.0	15.1	2365	35711
	Swimming (75 yards-min)	11.0	16.6	970	16112
	Rowing (200 watts)	12.0	18.1	320	5798
Estimated Total					**83755**

Table 4: Examples of typical weekday and weekend dietary intake during intervention 2.

Typical Week Day			Typical Weekend Day		
Food or Drink	**Portion**	**Time of Intake**	**Food or Drink**	**Portion**	**Time of Intake**
Granola	100g	9:00am	Sleep late & morning training fasted.		
Natural Yogurt Low fat Greek style	150g				
Coffee	200ml				
with sugar	15g				
Banana (peeled)	100g	11:00am			
Apple	100g				
Water	500ml		3 Eggs (Boiled)	180g	12:00am
Wholemeal bread Ham & Cheese Sandwich	146g	1:00pm	3 Brown Toast	120g	
			Butter light	20g	
Salt & vinegar crisps	30g		1 Can Baked Beans	415g	
Tomato Soup (tinned)	200g				
Strawberry (full fat) Yogurt	125g		Coffee	200ml	3:00pm
			with sugar	15g	
Coffee	200ml	3:00pm	Dairy Milk Bar	50g	
with sugar	15g				
Water	500ml				
Apple	100g	4:00pm			
Wholemeal bread toast (x2)	60g		Take Away: Chicken Tikka Masala	490g	6:00pm
Butter light (thin)	15g				
Chicken Breast	300g	7:00pm	Pilau Rice (cooked weight)	150g	
Mixed Vegetables	150g				
Basmati Rice (cooked weight)	150g		Garlic Naan	160g	
Water	500ml		3 x Large lager Beer (5.0% vol.)	1980ml	

Table 5: Energy intake and percentage macro-nutrient composition on week and weekend days.

Typical Week Day			Typical Weekend Day		
Macronutrient	**Amount**	**% Intake**	**Macronutrient**	**Amount**	**% Intake**
Protein	150g	23	Protein	146g	18%
Carbohydrates	340g	52	Carbohydrates	300g	36%
Fat	70g	25	Fat	116g	32%
Alcohol	0ml	0	Alcohol	1980ml	14%
Total energy	2560 kcals		Total energy	3240 kcals	
			Alcohol free energy	2770 kcals	