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THE EFFECTS OF A NOVEL HYBRID EXERCISE TRAINING PROGRAM ON BODY COMPOSITION, BODY WEIGHT AND ENERGY BALANCE IN SEDENTARY OVERWEIGHT/OBESE WOMEN

by

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Dedicated to my lovely wife Ioanna, beautiful daughters Emmanouela and Katerina, mother Aristea, and late father Emmanouil for their continual and exemplary patience, understanding, and encouragement to my career milestones. Thank you from the bottom of my heart for your sacrifices because without your support nothing could be happen!

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The decision of participating in a graduate program exactly twenty years after the beginning of undergraduate studies and an extensive working experience within the health, and fitness industry is really a unique challenge. But the intense desire for continuing self-improvement and professional development regarding the required knowledge, skills, and competencies of a leading and excellent professional can be the appropriate response to this challenge. Any new educational pathway such as a Master's degree with thesis can support efficiently this attitude and help to overcome every concern, insecurity, and difficulty toward lifelong learning. During this experience, many people supported me by providing a stimulating scientific environment that continually expands my knowledge base and help me to understand better the connection between science and practical application in the field of exercise for health, performance, and wellness.

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ABSTRACT

Alexios Batrakoulis: The effects of a novel hybrid exercise training program on body composition, body weight and energy balance in sedentary overweight/obese women.

(Under the supervision of Dr. Athanasios Jamurtas, Professor)

High-intensity interval training (HIIT) programs are promising for weight management and HIIT-type programs integrating endurance- and resistance-type exercises are an emerging trend in the fitness industry although not evidenced-based yet. This study aimed to examine the responses of body mass, body composition and energy balance in previously sedentary overweight/obese women to FFIT (Fun & Functional Interval Training), a novel, hybrid, and time-effective small group training program integrating cardiovascular and resistance exercises. Forty-nine healthy overweight or class I obese women (36.5±4.5 yrs.) were randomly assigned to either a control (C, N=21) or a training (TR, N=14) or a training-detraining (TRD, N=14) group. In weeks 1-20, TR and TRD trained with FFIT (three-weekly, divided in four phases, consisted of 8-12 whole-body exercises of progressively increased intensity and volume and organized in timed interval circuit form). In weeks 21-40, TR continued training whereas TRD not (detraining). Heart rate (HR), blood lactate, exertion, oxygen consumption and post-exercise oxygen consumption were measured for one session/phase/person and exercise energy expenditure (EE) was calculated. Energy intake (EI), habitual physical activity, resting metabolic rate (RMR), body composition, and body weight was measured at baseline, at mid-intervention and at post-intervention. FFIT reduced body mass by 6% (P=0.092; CI=-0.67/0.82), body fat by ~5.5% (P=0.000; CI=-0.44/1.05) and increased fat-free mass by 1.2-3.4% (P=0.000; CI=-1.20/0.30), strength (P=0.000; CI=-1.24/0.26) and endurance (P=0.000; CI=-1.00/0.4) by 24% using a metabolic overload of only 5-12 MET-hours/week. FFIT induced a long-term negative energy balance during both an exercise and a non-exercise day due to an elevation of RMR (6%-10%; P=0.012; CI=-1.12/0.37) and exercise-related EE. FFIT had an 8% attrition and 94%

attendance. Training-induced gains were attenuated but not lost following a 5-month detraining. These results suggest that a 10-month implementation of a hybrid, small-group, HIIT-type program resulted in a long-term negative energy balance that resulted in a progressive reduction of body and fat mass and increased performance.

Key words: *obesity, high-intensity interval training, functional exercise training, resting metabolic rate, energy balance*

ΠΕΡΙΛΗΨΗ

Αλέξιος Μπατρακούλης: Οι επιδράσεις ενός νέου υβριδικού προγράμματος άσκησης στη σύσταση σώματος, το σωματικό βάρος και το ενεργειακό ισοζύγιο σε υπέρβαρες/παχύσαρκες γυναίκες καθιστικής ζωής.
(Με την επίβλεψη του Δρ. Αθανάσιου Τζιαμούρτα, Καθηγητή)

Τα προγράμματα διαλειμματικής προπόνησης υψηλής έντασης (HIIT) είναι υποσχόμενα για τη διαχείριση του σωματικού βάρους και τέτοιου τύπου προγράμματα τα οποία συνδυάζουν ασκήσεις καρδιοαναπνευστικής αντοχής και μυϊκής ενδυνάμωσης με αντιστάσεις, αποτελούν μια αναδυόμενη τάση στη βιομηχανία της άσκησης, παρόλο που δεν είναι ακόμη τεκμηριωμένα. Αυτή η μελέτη σκόπευε να εξετάσει τις αποκρίσεις του σωματικού βάρους, της σύστασης σώματος και του ενεργειακού ισοζυγίου σε υπέρβαρες/παχύσαρκες γυναίκες καθιστικής ζωής σε ένα νέο, υβριδικό και χρονικά αποδοτικό πρόγραμμα άσκησης ολιγομελών ομάδων με τον τίτλο FFIT. Σαράντα εννέα υγιείς υπέρβαρες ή πρώτου βαθμού παχύσαρκες γυναίκες (36.5±4.5 ετών) συμμετείχαν εθελοντικά σε τρεις ομάδες [ελέγχου (Ε, N=21), προπόνησης (Π, N=14) ή προπόνησης-αποπροπόνησης (Π-Α, N=14) σε μια τυχαιοποιημένη κλινική μελέτη. Κατά τη διάρκεια των πρώτων 20 εβδομάδων, η Π και η Π-Α προπονήθηκαν με το FFIT. Στις επόμενες 20 εβδομάδες, η Π συνέχισε να προπονείται ενώ η Π-Α διέκοψε (αποπροπόνηση). Η προπόνηση πραγματοποιήθηκε τρεις φορές την εβδομάδα και χωρίστηκε σε 4 φάσεις. Η κάθε φάση αποτελούνταν από 8-12 ολόσωμες ασκήσεις προοδευτικά αυξανόμενης έντασης και ποσότητας, ενώ ήταν οργανωμένη σε μια μορφή χρονομετρημένης κυκλικής διαλειμματικής προπόνησης. Η καρδιακή συχνότητα, το γαλακτικό οξύ στο αίμα, η κλίμακα υποκειμενικής εκτίμησης της κόπωσης, η κατανάλωση οξυγόνου τόσο κατά τη διάρκεια όσο και μετά την άσκηση μετρήθηκαν για μία συνεδρία ανά φάση για κάθε εθελόντρια και υπολογίστηκε η ενεργειακή δαπάνη της άσκησης (EE). Η θερμιδική πρόσληψη εφτά ημερών (EI), τα ημερήσια επίπεδα σωματικής δραστηριότητας, ο μεταβολικός ρυθμός ηρεμίας (RMR), η σύσταση σώματος και το σωματικό βάρος μετρήθηκαν πριν, μετά από 20 εβδομάδες και μετά από 40 εβδομάδες παρέμβασης. Ανάλυση διακύμανσης επαναλαμβανόμενων μετρήσεων εφαρμόστηκε για την ανάλυση των δεδομένων (P<0.05). Το FFIT μείωσε το σωματικό βάρος κατά 6% (P=0.092; CI=-0.67/0.82), το σωματικό λίπος κατά περίπου 5,5% (P=0.000; CI=-0.44/1.05) και αύξησε την άλιπη μάζα κατά 1,2-3,4% (P=0.000; CI=-1.20/0.30), τη μυϊκή δύναμη (P=0.000; CI=-1,24/0,26) και την καρδιοαναπνευστική αντοχή (P=0.000; CI=-1.00/0.4) κατά 24% κάνοντας χρήση μιας μεταβολικής υπερφόρτωσης της τάξεως μόνο 5-12 MET-ώρες/εβδομάδα. Το FFIT επέφερε μακροπρόθεσμα ένα αρνητικό ενεργειακό ισοζύγιο τόσο κατά τη διάρκεια της ημέρας άσκησης όσο και της ανάπαυσης πιθανώς λόγω της αύξησης του μεταβολικού ρυθμού ηρεμίας (6%-10%; P=0.012; CI=-1.12/0.37) και της σχετιζόμενης με την άσκηση ενεργειακής δαπάνης. Το FFIT είχε 8% αποχή και 94% συμμετοχή. Τα κέρδη που αποκτήθηκαν από την προπόνηση εξασθένησαν αλλά δεν χάθηκαν κατά την περίοδο αποπροπόνησης διάρκειας 5 μηνών. Αυτά τα αποτελέσματα συνιστούν ότι μια 10μηνη εφαρμογή ενός υβριδικού προγράμματος διαλειμματικής προπόνησης για ολιγομελείς ομάδες οδηγούν σε ένα μακροπρόθεσμα αρνητικό ενεργειακό ισοζύγιο το οποίο επιφέρει μια προοδευτική μείωση του σωματικού βάρους και λίπους, καθώς και αύξηση της απόδοσης.

Λέξεις κλειδιά: *παχυσαρκία, διαλειμματική προπόνηση υψηλής έντασης, λειτουργική προπόνηση, μεταβολικός ρυθμός ηρεμίας, ενεργειακό ισοζύγιο.*

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LIST OF ABBREVIATIONS

ACSM: American College of Sports Medicine

ADL: Activities of daily living

BF: Body fat

BMI: Body mass index

CET: Cardiovascular exercise training

CWT: Circuit weight training

DXA: Dual-energy X-ray absorptiometry

FFIT: Fun and functional interval training

FM: Fat mass

FFM: Fat-free mass

FT: Functional training

HIIT: High-intensity interval training

HR: Heart rate

HRR: Heart rate reserve

IT: Interval training

MHR: Maximum heart rate

NSCA: National Strength and Conditioning Association

PA: Physical activity

RE: Resistance exercise

RM: Repetitions maximum

RMR: Resting metabolic rate

RPE: Rating of perceived exertion

VO_{2max}: Maximal oxygen uptake

WC: Waist circumference

WHO: World Health Organization

WHR: Waist-to-hip ratio

INTRODUCTION

Identification of the research problem

The body weight training, high-intensity interval training (HIIT), exercise for weight loss, personal and group personal raining, functional fitness, and circuit training are currently considered some of the top worldwide trends in the commercial, corporate, clinical, and community landscapes within the health and fitness industry (Thompson, 2016). In addition, the most recent epidemiology findings and future predictions by the World Health Organization (WHO) regarding the prevalence of overweight and obesity adult population indicate that more than one out of two in Europe and two out of three worldwide are and will be maintaining overweight (WHO, 2014). On the other side, physical inactivity rates have grown immensely worldwide (Hallal et al., 2012) although regular exercise induces many positive changes in health by lowering the risk factors for several chronic diseases. (Blair et al., 1996).

Furthermore, the global market report by the International Health, Racquet & Sportsclub Association (IHRSA) mentions a continual growth of the health club industry and notes that according to the consumers' report, weight management is one of the main goals for the majority of exercisers in the United States (IHRSA, 2016a). Participation by women 35-54 years old grew more than any other demographic category and the majority of female members use their health club for overall health and well-being and to maintain or improve physical fitness. Based on IHRSA research, participation rates for female club members focus primarily on group exercise classes (IHRSA, 2016b).

Additionally, lack of time has been described as one of the most frequent reasons to systematic exercise participation (Salmon, Owen, Crawford, Bauman, & Sallis, 2003; Trost et al., 2002). According to the latest Eurobarometer for sport and physical activity that was conducted by the European Commission (EC) the participation in fitness is clearly the number one ‘sport’ activity in Europe. Moreover, the improvement in health, physical performance, wellness, and weight management are the most important reasons for clients of fitness clubs who want to remain physical active through structured exercise programs in commercial setting at European level (EC, 2014). According to the above facts, a research project that impacts directly the health, fitness, and wellness industry may works as an important and crucial factor for the future of public health globally through the investigation of a novel training modality that engages overweight or obese people in structured exercise.

Importance of the study

The scientific research indicates that exercise modalities, which combine either functional fitness and body weight exercises or HIIT and circuit training improve the aerobic capacity and body composition (Fitri, Zakiah, Azhana, & Haari, 2015; Klika & Jordan, 2013; Miller et al., 2014; Myers et al., 2015). This exercise modality seems as an appropriate type of training that provides respected adaptations on cardiovascular health and weight management while is one of the most popular training programs globally (Smith, Sommer, Starkoff, & Devor, 2013). All these findings enhance the need of a study that will determine how effective is a novel training program that combines functional fitness, circuit training and HIIT on performance, health and wellness of sedentary, premenopausal overweight or obese women. There is very limited published data regarding the effects of circuit functional HIIT programs on the anthropometric profile and performance of sedentary overweight or obese women and especially when the occupational role of Weight Management Exercise Specialist is considered as one of the top and most attractive specializations for certified fitness professionals who train clients in either a one-on-one or small group setting within the next 10 years in Europe (Batrakoulis, Rieger, & Santos-Rocha, 2016).

Purpose of the study

Observing a lack of research investigating the chronic physiological and psychological responses to the top fitness trends the purpose of this study is the examination of the Fun & Functional Interval Training (FFIT) workout after a 10-month training period and a 5-month detraining period on body mass, body composition, energy balance and performance in sedentary, premenopausal overweight or obese women. Combining the majority of worldwide top fitness trends through an exercise intervention program, the study investigates the effectiveness of a novel, hybrid, and time-effective workout to improve many different components of health-related fitness on the most common type of global population.

Therefore, the application of a whole-body workout routine that combines cardiovascular exercise training (CET), resistance exercise (RE), and functional fitness training (FFT) in the context of HIIT may be more effective for successful weight management as well as promotion of health and overall well-being. In this study, we present a novel hybrid HIIT exercise training approach, the Fun and Functional Interval Training (FFIT) workout that combines interval training (IT), RE, and FFT performed in a small-group setting fashion and according to a periodized model of exercise prescription as an alternative approach for weight management. FFIT has been designed to be time-effective and attractive for participants to increase the adherence and compliance rate that seem to be of great concern in weight management programs (Burgess, Hassmén, Welvaert, & Pumpa, 2017).

The importance of this research project is focused on the need of a useful and evidence-based small group training, which is able to strengthen its influence on the fitness industry offering fitness professionals a chance to help more people while providing consumers with high-quality, recreational and science-based services. Especially under the circumstance of the current rise in overweight and obese individuals the role of a science-based, but fun and safe training program as well, is absolutely crucial for creating a more active and healthy society.

Study questions and hypotheses

Currently, there is no data available about the effects of circuit functional high-intensity training on body mass, body composition, energy balance and performance and also, the existing information about similar exercise modalities on the same variables is limited. For these reasons, this study was conducted and the aim was to find an answer to the following research questions.

1. Are there differences in body mass of sedentary, premenopausal overweight or obese women after a 10-month exercise intervention with the FFIT workout?
2. Are there differences in body composition of sedentary, premenopausal overweight or obese women after a 10-month exercise intervention with the FFIT workout?
3. Are there differences in performance of sedentary, premenopausal overweight or obese women after a 10-month exercise intervention with the FFIT workout?
4. Are there differences in energy balance of sedentary, premenopausal overweight or obese women after a 10-month exercise intervention with the FFIT workout?

The research hypotheses of the present study were:

1. FFIT workout decreases body mass in sedentary overweight/obese women.
2. FFIT workout improves body composition in sedentary overweight/obese women.
3. FFIT workout improves performance in sedentary overweight/obese women.
4. FFIT workout alters energy balance in in sedentary overweight/obese women.
5. FFIT workout demonstrates a high adherence and compliance rate.

The null hypotheses that were stated in order to control the research hypotheses were:

1. There will not be a statistically significant difference between pre- and post-testing of experimental groups on physical performance markers after a 10-month exercise intervention with the FFIT workout.
2. There will not be a statistically significant difference between pre- and post-testing of experimental groups on body composition markers and energy balance after a 10-month exercise intervention with the FFIT workout.

Study limitations

The limitations of the present study are:

1. The sample consisted only of women
2. The sample consisted only of premenopausal women aged between 30-45
3. The sample consisted only of sedentary and untrained individuals
4. The sample consisted only of overweight or obese individuals

Theoretical and operational definitions

Aerobic capacity: The maximum amount of oxygen (VO_{2max}) that the body can utilize during an exercise session.

Anaerobic capacity: Maximal work performed during maximum-intensity short-term physical effort in a single bout of continuous exercise.

Resistance training: A form of physical activity that is designed to improve muscular fitness by exercising a muscle or a muscle group against external resistance.

Repetitions maximum: The repetitions that can be performed with good form against a specific external resistance on a specific exercise.

Maximum strength: The greatest force that can be developed by the neuromuscular system in a single maximal voluntary contraction.

Oxygen consumption: The amount of oxygen taken up and utilized by the body per minute.
Resting metabolic rate: The minimum number of calories needed to support basic functions, including breathing and circulation.

Body composition: The estimation of relative proportions of fat, bone and muscle in the body.

Physical fitness: A general state of health and well-being that is achieved through a combination of proper nutrition, regular moderate-vigorous exercise, and sufficient rest.

Circuit weight training: An exercise modality that involves a series of exercise stations with relatively brief rest intervals between each station incorporating low resistance and high volume exercises that involves all major muscle groups in one continuous cycle.

Body Weight or Resistance HIIT: An exercise modality that involves alternatively relatively more intense bouts of work with those that are relatively less intense using bodily movements, weighted objects or devices for high repetition resistance activities while rest intervals vary on the intensity and duration of each segment.

Functional fitness training: An exercise modality that has been defined as having the physical capacity to perform activities of daily living in a safe and independent manner undue fatigue attempting to focus mostly on multi-joint movement and introduce controlled amounts of instability.

LITERATURE REVIEW

The epidemiology of obesity

Obesity is now considered an epidemic and a major health issue while its worldwide prevalence has doubled over the last decade (Seidell & Halberstadt, 2016). Additionally**, i**t is commonly accepted that a serious problem – and one of the most prevailing public health problems worldwide – is obesity, creating a strong concern not only in the scientific community, but also in both developed and developing societies (Flegal, Carroll, Kit, & Ogden 2012). Direct and indirect costs for the treatment of obesity and its comorbidities have been estimated to contribute significantly to total healthcare expenditures of a country posing a threat for the survival of public health care systems (Dee, 2014). Therefore, developing effective strategies and interventions to prevent and manage obesity is of great importance. Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health (Haslam & James, 2005) and there is a strong relationship among obesity and other medical chronic conditions and diseases.

More specifically, obesity is a metabolic disease that refers to the overfat condition, which is highly associated with comorbidities, including type 2 diabetes, dyslipidemia, hypertension, coronary heart disease, and many different types of cancer (ACSM, 2014). The main underlying cause of obesity is an imbalance between caloric intake and expenditure, in favour of the first, over a given period of time (Dhurandhar et al., 2015). Increased intake of energy-dense and unhealthy foods in combination with reduced physical activity (PA) are thought to be the main contributors to the obesity epidemic (Frühbeck, 2005). Anti-obesity interventions should aim at a 5-10% reduction in body mass (Riou et al., 2015) by promoting lifestyle changes favouring energy expenditure over overfeeding (Wadden, 2007). Despite the fact that such a decline may not normalize body mass of an obese adult, it will improve risk factors associated with obesity-related diseases (Laskowski, 2012).

The epidemic of obesity has grown at an alarming rate among adults, both at European and worldwide level (Saris et al., 2003) and is highly associated with the physical inactivity nowadays (Flegal, Kit, Orpana, & Graubard, 2013). Due to the modern way of living physical activity has largely eliminated as one of the fundamental stimuli from adults' lives (Blair, 2009). Active living is an optimal way of life for well-being and is considered as one of the most important elements in fighting all the biggest public health problems including obesity (Blair, Dunn, Marcus, Carpenter, & Jaret, 2010). The huge growth of noncommunicable chronic diseases including obesity provides clear evidence of this imbalance between lifestyle and physical requirements in adults nowadays (WHO, 2014). According to available data from Europe through the EC and the United States through the Centers for Disease Control and Prevention (CDC), only about 31% and 21% of the European Union (EU) and U.S. populations meet the guidelines of physical activity daily, respectively (CDC, 2014; EC, 2014).

Once considered a problem only in high income countries, overweight and obesity are now dramatically on the rise in low and middle income countries, particularly in urban settings (Hossain, Kawar, & El Nahas, 2007). Additionally, recent epidemiology statistics indicate that approximately 1.5 billion adults 20 years and older are overweight, and of these individuals, approximately 500 million are obese (WHO, 2014). Based on latest available data, more than half (52%) of the adult population in the EU are overweight or obese. More specifically, on average across EU member states, 17% of the adult population is obese when more than one-third (35%) of U.S. adults are obese (Flegal, Kit, Orpana, & Graubard, 2013). In addition, adult obesity is linked to comorbidities that have been attributed to a large number of deaths annually (Mokdad et al., 2000) and is considered the second leading cause of preventable death in the United States (Allison, Fontaine, Manson, Stevens, & VanItallie, 1999). Moreover, obesity reduces life expectancy by as much as 10 to 20 years and is associated with many health conditions (McArdle, F. Katch, & V. Katch, 2014).

In terms of diagnostic testing and criteria for obesity, body mass index (BMI) is a simple height-weight index that is commonly used for classifying overweight and obesity in adults. The BMI calculation divides an adult's weight in kilograms by their height in meters squared and the WHO developed guidelines that classified people with BMI greater than 25 kg/m^2 as overweight and those with BMI greater than or equal to 30 kg/m^2 as obese (WHO, 2000). Individuals who display BMI greater than or equal to 40 kg/m^2 are considered morbidly obese and have a higher risk of death and disability due to their weight (Lavie, Milani, & Ventura, 2009). While BMI does not measure body fat, it is considered one of the best ways to quickly approximate an individual’s degree of body fatness, as opposed to looking at weight alone. But despite its convenience and popularity, there are many concerns that BMI fails to consider the body’s proportional distribution of body fat and the composition of overall body weight.

Many theories and intervention methods have been developed for the treatment of obesity, and one of them relates to predictive models of body weight change, in order to examine the metabolic adaptations that occur by reducing weight in humans. These mathematical calculation models consider the reduction of body weight through metabolic mechanisms, such as changes in resting metabolic rate, fluid balance, thermal effect of food or behavioral compensation mechanisms such as intervention through diet, physical activity, or both simultaneously (Dhurandhar, et al., 2015). According to the literature review there are more than one thousand intervention articles, which were conducted on scientific databases such as PubMed, Scopus and Sport discus and are related to healthy adults who participated in diet-only interventions, physical activity or in a combination of both.

The effectiveness of diet, exercise, and diet plus exercise for weight loss in obese adults was examined many years ago through a meta-analysis that used 493 participants from more than 700 studies, which were conducted the period 1972-1997 (Miller, Koceja, & Hamilton, 1997). In this study, the data showed that a 15-week diet or diet plus exercise program produces a weight loss of about 11 kg, with a 6.6 +/- 0.5 and 8.6 +/- 0.8 kg maintained loss after one year, respectively.

The role of diet in weight management

The role of nutrition and the link between energy intake and obesity have been extensively studied. Recent research findings, by examining the importance of the effect of both the absorption frequency and the size of the portion on appetite, total energy intake and body mass index, demonstrate superiority of the absorption frequency in correlation with the increase in body weight (Mattes, 2014). An additional factor that influences nutrition and behavior generally is the daily caloric consumption through liquids as snacks to accompany the main meals and/or meal substitutes. According to the standards of modern nutrition in the Western world 25% of the daily calorie intake is via fluid consumption (alcohol, soft drinks, juices, energy drinks, soups, fortified beverages with other ingredients such as coffee, tea, etc), presenting even a gradually increasing trend in correlation with the prevalence of overweight and obese people of all ages worldwide. In particular, all these liquid foods, other than soups, are characterized by low satiety, increased frequency of consumption, low nutrient content of ingredients, resulting in increased daily energy intake and increased body mass index (Mattes, 2006).

Furthermore, when the nutritional intervention was tested exclusively for a period of one year in overweight adults comparing energy intake restriction by 10% and 30% respectively, no significant difference in the reduction of body weight was observed between the two approaches (Das et al., 2009). In the case study where the effect of two different types of protein diet was studied for a short period of four weeks, there was a greater reduction of body weight in the formula of the ketogenic diet with low carbohydrate consumption, compared to the non-ketogenic diet type with moderate carbohydrate consumption (Johnstone et al., 2008).

Additionally, in Das et al. (2009) survey, the purpose was to examine and compare the effects of a low dietary energy restriction in relation to a high-energy restriction, in order to facilitate long-term weight loss. The duration of the study was 1 year and trainees were divided into two groups. The first group applied nutrition with low (10%) energy dietary restriction, while the second group applied moderate (30%) energy dietary restriction. Both diets were differed in glycemic load. Thirty-eight (38) overweight men and women participated, aged 35±6 years with BMI=27.6±1.4 kg/m^2. The measurements made, included body weight measurement, basal metabolic rate and observance of dietary energy restriction by using 2H218O, satiety and eating habits. According to the results, the changes observed between the two groups in relation to body weight and saturation, were not of much significance. Weight loss difference of the trainees of the 2 groups within 12 months was not, also, significant. In conclusion, the results of this study are consistent with the results of other studies showing that reducing energy intake by 10-20% can lead, on the long run, to a weight loss.

Also in the Johnstone et al. (2008) study, the aim was to investigate the feeling of hunger, appetite and weight loss caused by a high protein diet, low carb (ketogenic) diet and a high protein and moderate carbohydrates (non-ketogenic) diet in obese men. Seventeen (17) obese men participated and were offered two high protein diets (30% of energy) for a four-week period. The one diet was ketogenic (4% carbohydrates), while the other was non-ketogenic (35% carbohydrates). Body weight was measured in a daily basis and the ketosis was monitored via plasma and urine sampling. Finally, hunger was assessed by using a visual analogue system. The results showed that the application of the ketogenic diet reduced hunger and lower food intake was observed in relation to the non-ketogenic diet.

Finally, the purpose of another study was to assess the participants' compliance with the diet for six months. In the survey participated 46 men and women who were randomly divided into four groups. The first group was the control group, the second group had as a goal to restrict calories, the third group to restrict calories via exercise and the fourth group had a low-calorie diet. Two weeks before the initiation of the intervention, the participants were given food, during the first 12 and the last two weeks as outpatients (Moreira et al., 2011). Conclusively, it was showed that adherence to diet is only achieved when all food is offered to the patients and also when participants are highly motivated. Based on above studies it is well-known and evidence-based that diet alone plays a key role to the treatment of obesity and is considered as a required tool for weight control.

The role of diet and exercise in weight management

According to a literature review regarding the role of combined intervention on weight loss, it is clear that many different diet interventions are able to achieve weight loss, but the role of exercise along with diet is very crucial in order to provide positive effects not only on weight control, but on many other health-related aspects as well. Specifically, the parameters of exercise training programs such as frequency, intensity, duration, and mode play important role considering an effective and life-long weight loss treatment (Volek, Vanheest, & Forsythe, 2005).

Another one systematic review assessed exercise or exercise and diet as a means of achieving weight loss in overweight or obese individuals using randomized controlled clinical trials. In this study, the data were based on 43 studies including 4376 participants and according to the results when exercise combined with diet resulted in a greater weight loss than diet alone (-1.1 ± 0.5 kg). Moreover, this review observed that weight loss is greater in case of high-intensity rather than low-intensity exercise training protocol (-1.5 ± 0.7 kg). The results of this review enhance the use of exercise as a weight loss intervention, particularly when combined with diet as a combined treatment option (Shaw, Gennat, O'Rourke, & Del Mar, 2006).

Additionally, a recent systematic review and meta-analysis (Clark, 2015) based on 66 studies examined the effectiveness of diet, exercise or diet with exercise on weight loss and physical fitness changes in overweight or obese adults (18-65 years old). The results of this study indicated that the combination of diet and exercise was the most effective treatment option in comparison with diet alone regarding the weight loss. Specifically, the combined intervention that applied resistance training was more effective than aerobic exercise or combination of resistance training and aerobic exercise.

Furthermore, considering a combined intervention through a severe calorie diet and regular exercise (aerobic and resistance training) on obese middle-aged adults, there was a 33% weight metabolic rate and to the persistence of the examinees to comply with those interventions (Byrne et al., 2012). Based on all the aforementioned emerges the need to investigate all these metabolic compensation factors leading to the reduction of body weight and concern interventions in both eating behavior and physical activity.

More specifically, in Byrne et al. (2012) survey, the aim was to examine the changes that will occur in the basal metabolic rate and body composition in obese men and women, after an exercise and diet intervention. Sixteen obese men and women participated, aged 41 ± 9 years with BMI = 39 ± 6 kg/m^2 onto whom the energy balance was measured before, after and twice during the 12-week diet with low energy foods (565-650 kcal/day) along with exercise. The type of exercise was aerobic with strengthening training. Moreover, body composition was measured by the method of high energy photon beam dual energy absorption and so was the basal metabolic rate. According to the results, the changes observed in body mass (-18.6 ± 5.0 kg), in fat mass (-15.5 ± 4.3 kg) and in lean mass (-3.1 ± 1.9 kg) did not differ significantly between men and women. Also, decreased body weight by 67% of the predicted value was found, but the range varied from 39% to 94%. The energy deficit was associated with a reduction in the basal metabolic rate, while the reduction of the basal metabolic rate is associated with the differences between actual and expected weight loss. In conclusion, weight loss after the intervention of exercise and diet was 33% lower than the expected loss.

The role of exercise in weight management

On the other side, the intervention solely of exercise as a metabolic compensation mechanism indicates that it is not sufficient by itself to bring optimal reduction in body weight in all individuals. Significant research has been conducted on the effects of structured exercise for the treatment of obesity and the majority of studies demonstrate that exercise alone has a small effect on weight loss independent of diet intervention. Additionally, exercise has been shown to have significant beneficial effects on important health markers such as cardiovascular and metabolic risk factors independent of actual weight reduction (Laskowski, 2012). More specifically, physical activity is any bodily movement produced by contraction of skeletal muscle that increases energy expenditure above basal level (ACSM, 2014) while exercise is any physical activity that is planned, structured, and repetitive for the purpose of improving or maintaining one or more components of physical fitness (Caspersen, Powell, & Christenson, 1985). Physical fitness training is a type of exercise training that promotes a general state of health and well-being providing the ability to perform aspects of sports, occupations and daily activities while enhances cognitive functioning and one’s ability to participate in leisure through a positive and satisfying social experience (Bianco & Paoli, 2015).

Unfortunately, the modern way of life with plenty of goods and the development of technology and automation condemns all of us in immobility (Hallal et al., 2012). The increased energy intake leads to excess body fat storage due to the reduction of energy consumption in physical activity that exceeds the daily energy needs. If overweight and obesity are accompanied with large waist circumference, they are associated with many growth factors predisposing cardiometabolic diseases, such as high triglycerides, fasting glucose, blood pressure and decreased high-density cholesterol levels (Grundy, Cleeman, & Daniels, 2005). More specifically, the correlation among obesity and other chronic diseases such as metabolic syndrome, type 2 diabetes and coronary heart disease, have been studied extensively (Lakka et al., 2002) and habit modification, relating to diet and physical activity, is proposed as a first therapeutic intervention. The common objective of the interventions is to maintain caloric balance, which will help stabilize body weight in order to prevent obesity while for weight reduction, conversion to a negative caloric balance is recommended through either a reduced energy intake and/or increased energy consumption.

Regular exercise acts "on many fronts" by, additionally, improving many different health markers such as insulin action, the regulation of glucose levels, treatment of dyslipidemia and hypertension (Pi-Sunyer et al., 2007), and also the beneficial effects are accompanied with a decrease in body weight. Furthermore, fitness level is an independent predictor of mortality risk factor (Wei et al., 1999), while physical inactivity is the fourth cause of death (WHO, 2009). Also, obese men, who had good physical condition, had significantly lower risk of health complications compared to slim men with not so good physical condition (Lee, Blair, & Jackson, 1999). The participation in a physical activity has a preventive effect on obesity and regular exercise benefits people with obesity (Bensimhon, Kraus, & Donahue, 2006). Therefore, the need for more individualization in training programs is created to overcome this very obstacle while facing body weight (King et al., 2007).

After probing for 13 weeks the effect of different doses of aerobic exercise to reduce body fat on overweight and untrained men, no significant difference was observed between the two different interventions, although the daily 60-minute intervention caused almost double energy expenditure than the 30-minute intervention (Rosenkilde et al., 2012). In the case of the study of high intensity exercise (>70% VO_{2max}) on obese adolescents and its acute effect on body weight reduction, no significantly increased energy expenditure was noted compared to similar age and normal weight or similar age, obese individuals, who performed a low intensity session at 40% VO_{2max} (Thivel et al., 2013). In addition, an extensive literature review on the energy compensation exclusively through exercise indicated that about 50% of cases of this type of intervention are mainly influenced by the interaction among the initial fat mass, the age of people and also the duration of the exercise program. Unlike the role of influence of sex, frequency, intensity, and volume of exercise on energy expenditure (Riou et al., 2015).

In regard to the investigation of weight loss in intervening exercise programs, the data are based on Riou's et al. (2015) review, as the obtained results during research are numerous and the above authors have published a very comprehensive review of 4,745 articles. In this body of evidence 71 studies were identified in which the average obtained compensation was 18%. It is noted that the authors refer to these compensations with the term "energy compensation", which is conducted through the mechanisms described in the previous section. A 48% variance in energy compensation was explained by the initial fat mass and the age of the subjects tested, as well as the duration of the intervention programs. More specifically, during longer interventions, the compensation was higher and so the weight loss was less. We could assume that this outcome is explained by the theory of motor learning, whereby learning a practice makes it less tedious by reducing energy expenditure required for its execution. Additionally, in programs that there is not a simultaneous control of diet, it could be true that exercise increases levels of hunger resulting in increased energy intake. Finally, three studies that were used in this review showed that weight loss is greater in low-impact rather than high-impact exercise.

In summary, systematic physical activity (PA) and/or exercise training may affect positively body composition and metabolic risk factors for obesity-related disorders even in the absence of weight loss (Verheggen, 2016). Furthermore, since exercise increases energy expenditure, less caloric restriction through diet may be required to obtain a similar body weight loss with less hunger, thereby increasing the chances of success. The ACSM recommends that obese individuals obtain more benefits from participating in PAs of moderate-to-high intensity that will gradually increase to at least 250 minutes/week; this amount of PA is more likely to promote weight loss, prevent weight regain and reduce risk factors for obesity-associated diseases (Lee, 2010).

Summary of exercise guidelines for overweight and obesity

Although continuous endurance exercise training (CET) may promote weight loss more effectively, ACSM also recommends the inclusion of resistance exercise training (RE) (Strasser, 2011) because it upregulates energy expenditure (EE) (Heden, 2011), increases resting metabolic rate (RMR) (Schuenke, 2002) and improves body composition and overall health (ACSM, 2014). According to the latest scientific guidelines for exercise prescription in overweight and obese individuals by the ACSM, an optimal long-term weight loss plan requires exercise engagement. More specifically, exercise can contribute up to a 300- to 400-kcal deficit per bout. Without any diet intervention and maintaining a constant food intake, an exercise program at an intensity and duration eliciting 300 to 400 kcal per session conducted three times per week could result in a 7-kg weight loss on a yearly basis (ACSM, 2014). The key role of exercise on weight management is highly associated with its impact to the resting metabolic rate (RMR) and fat-free mass (FFM). In terms of the most efficient exercise training modes and programming regarding the weight management, the combination of resistance training and cardiovascular exercise either separately or concurrently have been shown to make the greatest improvement to body composition, cardiovascular and musculoskeletal fitness, and metabolic health in both sedentary and overweight or obese adults (Ho, Dhaliwal, Hills, & Pal, 2012; Myers, Schneider, Schmale, & Hazell, 2015; Sillanpaa et al., 2009;). In addition, regular exercise may help to control appetite and improve psychological attitude when trying to lose weight (Lasikiewicz, Myrissa, Hoyland, & Lawton, 2014).

A systematic training program is designed with respect to patients' difficulties and complications, their weakness, the level of mobility, possible problems in their joints and even with respect to cardiovascular or psychological problems. In each program planning any intervention on the parameters of exercise (frequency, intensity, time, and type) must be gradual and take place with a personalized approach. The physical exercise recommendations for overweight and obese individuals suggest a range of exercise intensity indicated by maximum heart rate (MHR). The exercise intensity is the characteristic of exercise that depends on the patient's physical condition, their ability and the complications of the disease. The different intensity levels that have been proposed are: from 70% (Kanaley, Weatherup-Dentes, Alvarado, & Whitehead, 2001) up to 85% of MHR (Rice, Hong, & Perusse, 1999). The duration of the session of exercise for people who have not been previously exercised is, for example, 30-45 minutes of continuous aerobic exercise, such as walking. More specifically, according to the ACSM guidelines for the development and maintenance of cardiorespiratory fitness for endurance exercise it is suggested a frequency of 5 or more days per week with an intensity of exercise of 60-75% of MHR with duration of at least 30 minutes per session (ACSM, 2014).

Target progressively increasing to a minimum of 150 minutes per week of moderate-intensity physical activity to optimize health and fitness benefits. In addition, progress to higher amounts of exercise and physical activity reaching at least 250 minutes per week to promote long-term weight control. As the physical condition of an overweight/obese individual is improving, the duration can be gradually increased to reach 60-90 minutes. For weight reduction, is recommended one hour of moderate exercise per day (Ross, Janssen, & Dawson, 2004). The frequency of exercise sessions is recommended to be 3-4 times a week (Jakicic & Otto, 2006). The normal benefits of exercise last 2-72 hours after the exercise session (Galbo, Tobin, & van Loon, 2007), while at the same time are reversible after the exercise having been terminated (King, Baldus, Sharp, Kesl, Feltmeyer, & Riddle, 1995). In order the aerobic exercise not to become monotonous and to be more effective, it can be combined with strength training exercise. In fact, the exercise of both aerobic or strength training form should not represent two different therapeutic tools, but while having different effect to complete each other (Poirier & Després, 2001; Maiorana, O'Driscoll, Goodman, Taylor, & Green, 2002). Additionally, there is a theory that a multi-mode training, which incorporates two or more modes of cardiorespiratory exercise can function as an appropriate strategy in order to protect the body from getting overly fatigued from overuse of the same muscles in the same movement patterns. This technique helps to thwart the occurrence of musculoskeletal system stress, and aids in the prevention of muscle soreness and injuries. Therefore, theoretically, a person will be able to safely do more work more frequently, which equates to higher total energy expenditure and fat utilization (ACSM, 2014).

An examination of the evidence in regard to resistance training for overweight and obesity, the ACSM guidelines suggest a frequency of 2-3 sessions per week using whole body routines focusing on large muscle groups with an intensity of 40-50% of one-repetition maximum (1RM), which is very light-to-light intensity for sedentary overweight or obese individuals beginning a resistance training program. Target progressively increasing to an intensity of 60-70% 1RM, which is a moderate-to-vigorous intensity for novice to intermediate exercisers who are overweight or obese and have already some experience with supervised resistance training programs (ACSM, 2014). Moreover, the variety of resistance training programs can play a crucial role in helping physically inactive and novice overweight or obese people stay motivated by designing and modifying appropriate exercise protocols that enhance adherence and engagement in exercise training intervention. Programs should be designed to meet each person's unique health and fitness goals, motivation, and training preferences (Westcott et al., 2009). This can be range from a program with exercises for all major muscle groups performed two to three times per week to full-body circuits designed to boost the metabolism and enhance weight loss (Skinner, Bryant, & Merrill, 2015).

Undoubtedly, the exercise is beneficial to health and contributes to the physical and mental well-being. According to the literature, they exist some appropriate intervention strategies for weight loss and prevention of weight regain for adults (Donnelly et al., 2009) while exercise is considered as a key part of a behavioral intervention for long-term weight loss and maintenance (Lang & Froelicher, 2006). At the same time, it reduces the risk of various metabolic diseases and their complications (Blair et al., 1996; Zachwieja 1996), and is not considered only as an efficient tool for weight control (Stefanick, 1993). It has been suggested that the moderate-to-vigorous leisure-time physical activity diminishes the magnitude of all five risk factors that are associated with the metabolic diseases and disorders such as diabetes mellitus and metabolic syndrome (ACSM, 2014).

Despite the progress in the field of exercise and the number of research findings that make it a key factor of prevention and treatment of obesity, the systematic programs are assessed as unrealistic and do not promote a long-term adherence and engagement in evidence-based exercise modalities. This situation is combined with the absence of structures adjusted to apply science-based and systematic supervised exercise programs on a large scale at worldwide level that could be used as an important means of overcoming inactivity, overweight and obesity in adults.

According to the position statement of the ACSM, HIIT, CWT, and FFT induce the improvement of cardiovascular endurance, musculoskeletal health, and functional capacity in healthy adults (Garber et al., 2011). Additionally, fitness professionals who are interested in providing clients with the optimal results in less possible time, they always seek some innovative training methods and protocols (Paton & Hopkins, 2005) that are able to be more efficient and time-effective than some similar traditional options (Jones, Parker, & Cortes, 2011). However, other types of exercise modalities such as high intensity interval training (HIIT) and approaches combining CET and RE exercises have been used to improve body profile, performance and health (Myers et al., 2015).

Effects of interval training on body composition and performance

It has been documented that high-intensity interval training (HIIT) can also be considered as a time-efficient training model in comparison with the CET. For example, in the studies of Burgomaster et al. (2005) and Gibala et al. (2006), when they examined the physiological responses to these two exercise modalities in recreationally active adults, the time consumed to sprint interval training (SIT) was four times less than the time consumed to traditional endurance training.

HIIT consists of alternatively repeated work intervals of high-intensity exercise with rest intervals of low-intensity exercise or complete rest and has become an increasingly popular exercise modality due to its potentially large effects on aerobic and anaerobic capacity, and short time requirement (Cress, Porcari, & Foster, 2015; Foster et al., 2015; Kilpatrick, Jung, & Little, 2014). HIIT is not only considered a time-efficient approach compared to traditional CET (Foster et al., 2015) but it has also been shown to improve physical fitness components within a short time period compared to the traditional CET (Hazell, MacPherson, Gravelle, & Lemon, 2010; Ziemann et al., 2011) and induces physiological adaptations that improve both health (Gibala, Little, Macdonald, & Hawley, 2012; Gremeaux et al., 2012) and performance (Gillen & Gibala, 2014) of healthy adults. Many researchers have already studied the effects of HIIT in healthy, sedentary overweight or obese adults finding improvements in aerobic capacity (Lunt et al., 2014; Trilk, Singhal, Bigelman, & Cureton, 2011), body composition (Gremeaux et al., 2012; Hazell, Hamilton, Olver, & Lemon, 2014; Trapp, Chisholm, Freund, & Boutcher, 2008), insulin resistance (Whyte, Gill, & Cathcart, 2010), RMR (Kelly, King, Goerlach, & Nimmo, 2013), hormones that increase metabolism (Racil et al., 2013), lipid profile (Miller et al., 2014), and skeletal muscle metabolism (Schjerve, 2008).

Additionally, a recent study investigated a 6-week novel multimodal HIIT that demonstrated a significant increase in muscle function and metabolic performance in females (Buckley, 2015). Finally, in the McRae et al. (2012) study, an interval-style multimodal methodology in which only bodyweight exercises and an extremely low volume have been used for a 4-week intervention period showed improvements in both cardiorespiratory endurance and muscular endurance in recreationally active young females.

On the other side, Foster et al. (2015) have shown that a HIIT program based on Tabata's study (Tabata, 1996) is not more efficient than conventional exercise training modalities (e.g. steady-state and Meyer protocol). In this particular study, researchers did not find significant differences between these three protocols regarding the effects on aerobic and anaerobic capacity in untrained young adults. More specifically, according to the measures, Tabata protocol was significantly less enjoyable than the other two protocols (Foster et al., 2015). In another study that was conducted by Nybo et al. (2010), the comparison between HIIT and moderate intensity prolonged running showed a greater increase of aerobic capacity in HIIT group, but the improvement was better on body composition in the group that performed moderate intensity prolonged running. Finally, a meta-analysis by Bacon et al. (2013) investigated 37 articles, which had examined the effect of HIIT on cardiorespiratory endurance in either healthy sedentary or recreationally active adults. According to this review, HIIT induced slightly higher improvements compared to continuous traditional training.

Effects of circuit weight training on body composition and performance

Circuit weight training (CWT) training is designed to develop general, all-round physical and cardiovascular fitness (Morgan & Adamson, 1961) and is a form of resistance training using high volume and low intensity exercises with short rest intervals while involves exercising all major muscle groups in different stations in a format of one continuous cycle and alternating between the different movement patterns to allow for muscle recovery (Gettman & Pollock, 1981). The implication of traditional circuit weight training has been widely investigated over a period of years as an exercise modality that improves of physical performance, wellness, and health in adult population (Marx et al., 2001; Waller, Miller, & Hannon, 2011). More specifically, a continuous circuit training protocol at a low intensity (40% 1RM) and without aerobics stations, can be an efficient workout for cardiorespiratory adaptations (Gotshalk, Berger, & Kraemer, 2004). Additionally, a high-intensity circuit training using only bodyweight exercises improve body composition and health markers while is considered as a time-effective and attractive exercise modality to individuals who seek to get the maximum possible results in minimal time (Klika & Jordan, 2013). In general, using body weight as resistance during circuit training may be one of the emerging and most popular training methods in the global health and fitness industry nowadays (Thompson, 2016). Recent evidence suggests that high-intensity intermittent circuit-style resistance training protocols may be considered more efficient than traditional steady state sustained-effort aerobic work or traditional resistance training programs (Klika & Jordan, 2013).

Furthermore, this training method induces decrease of body fat in physically inactive middle-aged women with a normal BMI (Ferreira et al., 2010) and improves muscular strength, body composition, waist-to-hip ratio (WHR), waist circumference (WC), and blood lactate (BLA) production in overweight middle-aged untrained (Paoli et al., 2010). Applying the CWT in overweight middle-aged it has been observed a significant decrease on health markers, such as hypertension and blood lipids in comparison with the traditional endurance training and low-intensity circuit training (Paoli et al., 2013). Additionally, CWT may slightly increase resting energy expenditure (REE) and decrease respiratory rate (RR) 22 hours post-workout (Paoli et al., 2012). The combination of cardiorespiratory training and resistance training is a basic methodology in exercise programming for physical performance and health of middle-aged and older adults with no risk factors for chronic diseases (Kraemer, Ratamess, & French, 2002; Takeshima et al., 2004; Wood et al., 2001). Moreover, CWT contributes to the decrease in risk factors for metabolic diseases and coronary artery disease (CAD) and improves significantly lipid profile (Fett, Fett, & Marchini, 2009).

Furthermore, three different CWT protocols that included resistance training exercises and steady state aerobic or/and HIIT induce significant acute effects on BLA, heart rate (HR), and rating of perceived exertion (RPE) in recreationally active women (Skidmore, Jones, Blegen, & Matthews, 2012). A recent study has implied that a multimodal circuit training program including a variety of exercise modalities such as bodyweight strength training, traditional resistance training, and functional strength training using mobile equipment tools (e.g. kettlebell and battle rope) improves aerobic capacity and muscle strength in sedentary young females after 5 weeks of intervention (Myers et al., 2015).

Effects of functional training on body composition and performance

However, overweight/obese individuals may also need other types of exercise to address obesity-related problems such as neuromuscular deficits and reduced mobility (Garber, 2011). Functional training (FT), for example, utilizes movements that affect the entire neuromuscular system by simulating common movements and activities to improve physical capacity to perform activities of daily living (Miller et al., 2014; Myers et al., 2015; Sperlich et al., 2017).

FT has its origins in physical therapy and rehabilitation. (O'Sullivan & Schmitz, 2014). This training mode uses exercises that train the entire neuromuscular system by simulating common and fundamental movements from real life and uses movement patterns that take place in many different settings such as home, work or in sports enhancing balance, coordination, and core stability (Collins, Rooney, Smalley, & Havens, 2004). Additionally, it attempts to focus mostly on multi-joint movement and introduce controlled amounts of instability (Gambetta, 2002). More specifically, functional strength training focuses on exercising the body as an integral unit applying full-body movements rather than working a particular muscle or group of muscles independently and likely in separate sessions on a weekly basis applying split routine workouts (Santana, 2016). In general, functional training is becoming increasingly popular (Thompson, 2016) because it offers exercisers a practical way to improve their abilities to safely, effectively, and efficiently perform ADL and recreational sports activities (Boyle, 2010). There is a research gap in the literature regarding the FT and its effects to physiological and metabolic adaptations in healthy adults compared to the traditional resistance training. There are only few studies that investigate chronic adaptations to body composition, physical performance, health, and wellness, and especially in sedentary overweight or obese individuals. More specifically, this type of training induces significant improvements in functional capacity (de Vreede, Samson, van Meeteren, Duursma, & Verhaar, 2005; Milton, Porcari, Foster, & Udermann, 2008; Whitehurst, Johnson, Parker, Brown, & Ford, 2005) and body composition (Wiszomirska, Krynicki, Kaczmarczyk, & Gajewski, 2014) in elderly while improves musculoskeletal fitness health and flexibility in young adults (Kibele & Behm, 2009; Weiss et al., 2010).

Additionally, in the Balachandran et al. (2016) study, functional strength training improves physical function in elderly compared to traditional strength training when these two exercise modalities use similar movement patterns, but different equipment (e.g. machines vs. cables) and different body positions during the execution of exercises (e.g. seated vs. standing). Also in the Neves et al. (2015) study, a 4-month circuit functional training program induced significant improvements on body composition, motor fitness components, and lipid profile in postmenopausal untrained women. Moreover, it is suggested that FT increases adherence to regular exercise and engagement in structured training programs (Williams, Hendry, France, Lewis, & Wilkinson, 2007). In addition, high-intensity group fitness programs seem to be more attractive to the overweight and obese participants rather than traditional aerobics classes or traditional resistance training machine-based workouts. According to these research findings, participants who were engaged in this exercise modality improved significantly enjoyment, adherence, and intentions to systematic exercise experience. (Heinrich, Patel, O'Neal, & Heinrich, 2014).

During the last 10 years, functional training equipment has been widely attractive and refers to types of equipment, which allow human body to get a full freedom of movement that can mimic various life activities and tasks. Kettlebells, battling ropes, medicine balls, and suspension exercise devices are considered as the most popular, widely used and evidence-based pieces of this kind of equipment in the health and fitness setting. More specifically, these exercise training devices have been used effectively to combine both new physical challenges and diversity into a workout routine while providing both resistance training and aerobic exercise benefits and focusing on goal-specific activities (Stanforth, Brumitt, Ratamess, Atkins, & Keteyian, 2015).

METHODS

Study design

This study was a controlled randomized, three-group, repeated measures clinical trial. Participants were randomly assigned to one of three groups: (a) a control group (C, N=21; age: 36.7±4.1 years; height, 1.65±0.05 m) that participated only in measurements, (b) a training group (TR, N=14; age, 36.9±4.3 years; height, 1.64±0.04 m) that participated in the supervised 40-week FFIT workout exercise training program, and (c) a FFIT training-detraining group (TRD, N=14; age, 36.4±5.0; years; height, 1.66±0.05). During the first 20 weeks, TR and TRD followed exactly the same training protocol. At the end of this period, TR continued training for 20 more weeks whereas TRD terminated training for 20 weeks (detraining). Initially, participants were familiarized with exercises and overload patterns to be used in FFIT (four sessions). Anthropometric, metabolic, daily nutritional intake and habitual PA and performance were measured in all groups at baseline, at 20 weeks (mid-training) and at 40 weeks (post-training/detraining). Intensity was monitored throughout each training session. Blood lactate concentration (BLA), exercise oxygen consumption (VO_2) and excess post-workout oxygen consumption (EPOC) were measured during and after a training session of each phase of FFIT (one session/phase). Measurements at 20 and 40 weeks were performed 5 days after the last training session. The experimental flow chart is shown in Figure 1.

Participants

A preliminary power analysis (based on previous studies examining the effects of prolonged exercise interventions on body mass and composition) using an effect size of >0.55, a probability error of 0.05, and a power of 0.9 for 3 groups and 3 measurements points suggested that a sample of 36 participants was necessary to identify statistically meaningful trial effects among serial measurements (Huntel et al., 2008; Miller et al., 2014; Neves et al., 2017). The characteristics of subjects are shown in Tables 4 and 5.

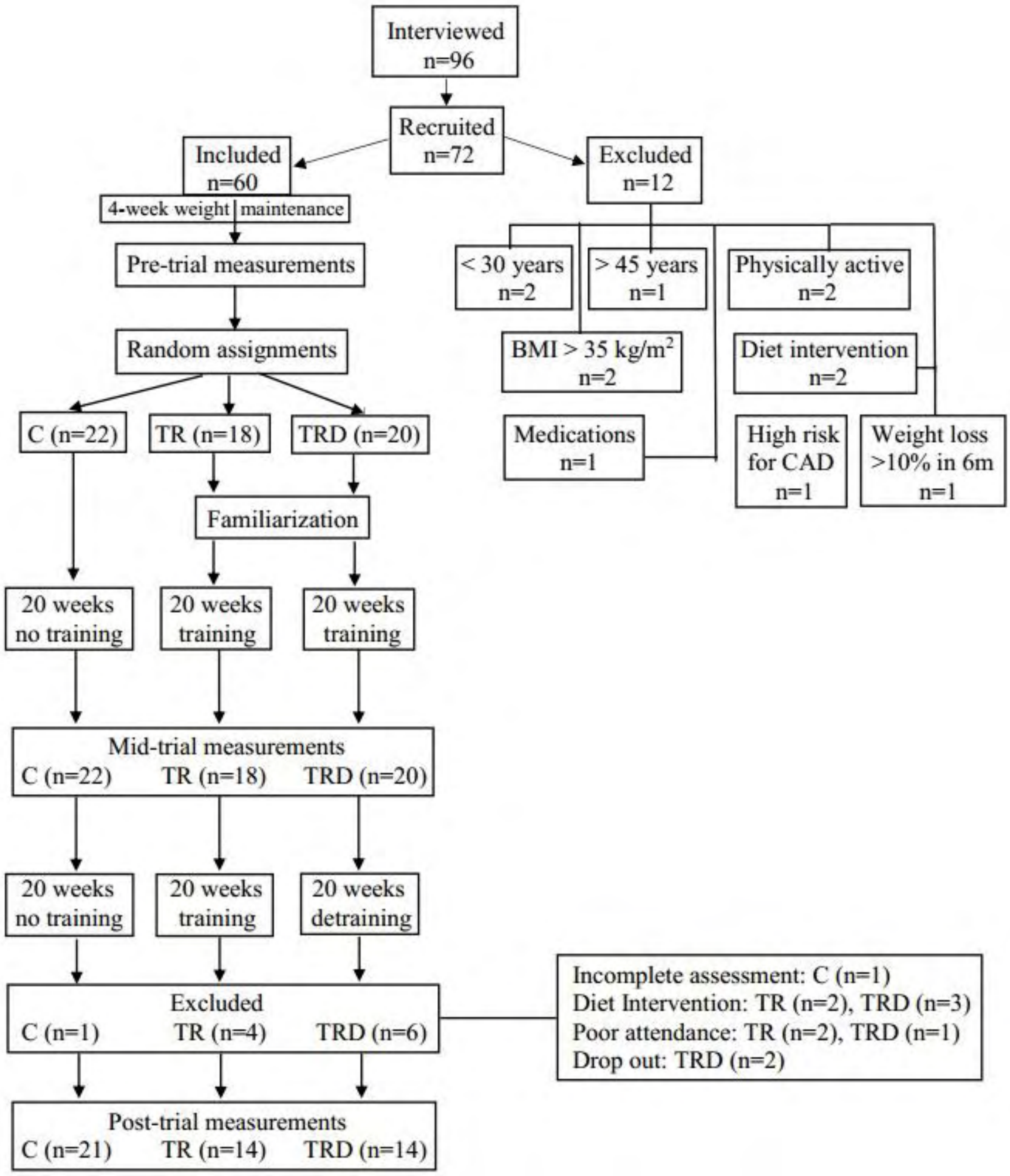

Figure 1. The experimental flow chart.

C, control group; TR, training group; TRD, training-detraining group; BMI, body mass index; CAD, cardiovascular diseases; m, months.

Initially, 96 healthy females were interviewed, 72 were recruited and 60 (12 were excluded because they did not meet the inclusion/exclusion criteria) entered the study and 49 completed it. Data from 5 women (2 in TR, 3 in TRD) were not used because they reduced their daily nutrient intake during the study. Three other women (2 in TR, 1 in DTR) were excluded due to poor attendance, 2 women (in DTR) dropped out, and 1 woman in C failed to participate in all measurements (Figure 1). Participants were recruited using fliers posted in the local community, social media, and by word of mouth.

According to the inclusion criteria of this study, women were able to participate in the research project only if they met the following criteria:

1) Physically inactive (<7,500 steps/day; VO_{2max} <30 ml/kg/min)

2) Premenopausal women aged 30-45 years

3) Overweight or obese class 1 (BMI=25-34.9 kg/m^2)

4) They had medical clearance and no signs, symptoms or diagnosis of serious health complications or physical disability or other medical condition compromising safe participation in exercise training

5) Non-smokers for ≥6 months before the study

6) Not following a diet intervention or using nutritional supplements/medications before (≥6 months) and during the study

7) They had no weight loss greater >10% of body mass ≤6 months before the study

8) Participation in ≥80% of total exercise sessions

9) They had no symptoms of depression

All procedures were in accordance with the 2013 Declaration of Helsinki and approval was obtained from the Institutional Ethics Committee. This trial was registered at clinicaltrials.gov as NCT03134781.

Exercise intervention

FFIT, a hybrid small-group (5-10 women/session) training modality was used in this study. FFIT was performed 3 times/week with 48 hours recovery between sessions for 40 weeks. All sessions were supervised and instructed by the same qualified exercise specialists. All sessions were conducted with the use of asynchronous music that was playing in the background but without any instruction to participants to perform exercises in synchronization with musical tempo (Karageorghis & Terry, 1997; Karageorghis et al., 2010; Karageorghis, Terry, Lane, Bishop, & Priest, 2012). During the first 20 weeks, training was divided in 3 distinct phases characterized by a progressive rise in exercise intensity and volume from phase 1 to 3 (Table 1). During the second 20 weeks (phase 4), training maintained the same intensity and volume of phase 3 but the work-to-rest ratio was varied every 2 weeks to promote further improvement (Table 1). Exercises in a FFIT workout routine were placed in an order to allow for either opposing muscle groups (i.e. upper vs. lower body) to alternate between resting and working in subsequent exercise station (Klika & Jordan, 2013) or to alternate between whole-body aerobic, whole-body resistance or core stabilization exercises. The objective was to use a hybrid structure that allows for a proper form and technique of exercises while maintaining a high-intensity stimulus. More specifically, all exercises (Table 2) incorporated whole body movements using bodyweight as resistance (Klika & Jordan, 2013) or adjunct portable modalities such as suspension belts, balance balls, kettlebells, medicine balls, battle ropes, stability balls, speed ladders, foam rollers and resistance bands (Stanforth, 2015).

Each session was preceded by a 10-min warm-up (consisting of low-intensity endurance exercise, stretching exercises and mobility movement patterns) and followed by a 5-min cool-down period (consisting of walking and stretching exercises). Exercises (10-12 per session) were performed in a timed circuit fashion that involved working or resting intervals of a prescribed time (Table 1). Participants performed as many repetitions as possible at each exercise station while maintaining proper form. Each session consisted of alternate stations emphasizing whole body aerobic, upper body resistance, lower body resistance, core stabilization and whole body resistance. Verbal encouragement was provided to participants. For resistance-type exercises, participants were encouraged to use a comfortable weight at the beginning of the study and progress to heavier weights as they felt more comfortable during the intervention. Heart rate (HR) was monitored (Polar Team Solution, Polar Electro-Oy, Kempele, Finland) throughout each session and mean and maximal HR were recorded. RPE was recorded at the end of each round and mean session RPE was calculated.

Anthropometric measurements

Height and body mass were measured to the nearest 0.1 cm and 0.1 kg, respectively, using a beam scale (SECA 220, Hamburg, Germany) and BMI was calculated by dividing the weight by the height squared (WHO, 2000) using the following formula: BMI = weight / (height x height). Waist (WC) and hip circumferences (HC) were measured using a Gullick II tape and waist-to-hip ratio (WHR) was calculated by dividing the waist by the hip measurement (WHO, 2008). According to the WHO protocol regarding circumference measurements, the waist circumference (WC) should be measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, using a stretch-resistant tape that provides a constant 100 g tension (WHO, 2008). Hip circumference should be measured around the widest portion of the buttocks, with the tape parallel to the floor. For both measurements, the participant should stand with feet close together, arms at the side and body weight evenly distributed, and should wear little clothing. The subject should be relaxed, and the measurements should be taken at the end of a normal respiration. Each measurement should be repeated twice and if the measurements are within 1 cm of one another, the average should be calculated. If the difference between the two measurements exceeds 1 cm, the two measurements should be repeated (WHO, 2008).

Body composition measurements were collected utilizing a whole-body DXA scan (Lunar Prodigy Advance, GE Healthcare Lunar, Madison, WI, USA), which is an image laboratory method, minimally invasive, used for indirect assessment of body composition at the molecular level, in a three compartment model and is considered as the gold standard for the assessment of fat mass (FM), fat-free mass (FFM) and bone mineral density (BMD) in overweight/obese adults (Andreoli, Scalzo, Masala, Tarantino, & Guglielmi, 2009; Brownbill1 & Ilich, 2005; Rothney, Brychta, Schaefer, Chen, & Skarulis, 2009). Version 12.2 of the enCORE software package (GE Lunar Healthcare Corp.) was used for DXA analysis. In this method, two low-energy x-ray beams that have a different frequency, pass through the body and the subject removes all metal accessories while lying in a supine position on the DXA scanning and with rectilinear scanning the body is divided into a series of pixels. The pixel division is based on the photon attenuation. This attenuation is measured with the two different energies. DXA gives an R value, which reflects the ratio of the attenuation of the two energies. With suitable calibration, it is possible to divide fat and lean fractions from soft tissue in the areas where there is no bone. To produce total body fat and lean soft tissue estimates, the composition of the areas of soft tissue with no bone is extrapolated to the soft tissue overlying bone (Plank, 2005.). The body composition characteristics of subjects are shown in Table 5.

Performance measurements

VO_2peak was measured separately from the other measurements, since the other tests required overnight fasting. VO_2peak was assessed during a graded maximal exercise testing

(GXT) using the modified Balke protocol (Balke & Ware, 1959) on a motor-driven treadmill (Precor 954i, Woodinville, WA, USA). Balke test was selected as a widely-used treadmill walking test suitable for sedentary or physically inactive individuals. Subjects breathed through a one-way valve (Hans-Rudolph 1400) while wearing a nose clip and were acclimated to this device prior to testing. Expired concentrations of O_2 and CO_2 were analyzed by portable open-circuit spirometry system (Fitmate Pro, Cosmed, Chicago, IL, USA) in 15-second intervals (Overstreet, Bassettr, Crouter, Rider, & Parr, 2016). Heart rate was continuously monitored by a heart rate monitor (F80, Polar Electro-Oy, Kempele, Finland) and perceived exertion was obtained verbally with the RPE scale (Borg, 1982) every 3 minutes at the end of each stage. Resting data were collected for 3 minutes prior to warm-up. The test was started with 5 minutes of warm-up at a speed of 4.5 km/h. Following warm-up, the slope of the treadmill was set to 0% and was increased by 2.5% every 3 minutes while used a constant walking speed of 5.5 km/h during the test. Attainment of VO_{2peak} was verified by the achievement of one of the five following criteria: (a) a respiratory exchange ratio (RER) of ≥ 1.1; (b) a change in VO_2 of < 2.1 ml/kg/min with increasing exercise intensity; (c) heart rate ±10 beats per minute of the age-predicted maximum (220-age) at the end of the exercise test; (d) a RPE of ≥ 17; and (e) volitional termination due to exhaustion (Edvardsen, Hem, & Anderssen, 2014). Additionally, respiratory gases were measured during recovery in sitting position immediately after the test for 5 minutes.

Maximal strength (1RM) was measured bilaterally on a horizontal leg press machine (Panatta Sport, Apiro, Italy) after a familiarization trial using standard procedures (ACSM, 2013) with an intraclass correlation coefficient (ICC) for test-retest trials of 0.88. The 1RM test was completed in a separate session and took place at a fitness club using the equipment of resistance training room. More specifically, 1RM lower body strength was assessed for one resistance machine instead of free weight exercise due to lack of familiarity with exercise technique and using a standard protocol for novice and untrained individuals (ACSM, 2013). In addition, compared with free weights, resistance machine offer a convenient, safe and easy way to test maximal strength in some populations, including the elderly, cardiac patients, adolescents, and some sedentary populations (Garhammer, 1987). Maximal strength was measured as the maximum weight a participant could lift in horizontal leg press machine with a proper execution through the full range of motion with no help.

Participants warmed up with 5 minutes of light aerobic exercise followed by the selected exercises. For each exercise, a warm-up set of 12-15 comfortable repetitions was performed using a low resistance. After 1-minute rest interval, a set of 8-10 repetitions was performed at 50-60% of the perceived 1RM. After a 1-minute rest interval, a set of 3-5 repetitions was performed at 60–80% of the perceived 1RM. Subsequently, 2-3 maximal trials were performed to determine the 1RM with 2-3 minutes rest interval between trials. A complete range of motion and proper technique was required for each successful 1RM trial. The tests required the participants to complete as many leg presses as possible with no rest until muscle failure while verbal encouragement was given to the subject.

Subjects seated on the machine with their back flat on the back support and put their feet at a shoulder width and in the middle of the platform. In the starting position, the legs of participants were extended, but without locking out the knees. During the movement, participants slowly lowered the platform until their thighs approached their torso (knee bending no more than 90^{o}) and without raising their hips from the pads (inhalation) and then pushed the platform (exhalation) to the initial position. The results of the assessment of VO_{2max} and 1RM are shown in Figures 2.

Measurement of resting metabolic rate

RMR was measured in the morning (07.00-09.00) after an overnight fast with participants in a supine position following a 15-min stabilization period by taking 30 consecutive 1-min VO_2/CO_2 measurements using a portable open-circuit indirect calorimeter with a ventilated hood system (Fitmate Pro, Cosmed, Chicago, IL, USA) following a standard calibration protocol. All participants were instructed to relax and avoid hyperventilation or sleep during data collection in a quiet, softly lit and well ventilated room at 22-24°C. Subjects lay supine on a comfortable bed and oxygen uptake was measured using a ventilated hood system. The gas analyzer was calibrated using 26% oxygen (O2) and 4% carbon dioxide (CO2) according to the manufacturer's instructions. O2 was analyzed by using paramagnetic analyzers and CO2 by using infrared analyzers; alternatively, a mass spectrometer was used to measure the gas concentrations (Compher et al., 2006). The 24-hour EE was calculated using the Weir equation (Weir, 1949) and was expressed per 24 hours while has a precision to within 0.5-2% of actual (Levine, Schleusner, & Jensen, 2000). The results of the assessment of RMR are shown in Table 5.

Measurement of exercise-induced caloric expenditure and blood lactate

Exercise energy cost (EEC) and EPOC (during post-exercise recovery until VO_2 was stabilized at resting levels) (Scott, 2005; Fountaine, 2015) was measured using a portable indirect calorimetry system ($Vmax_{ST}$, Sensormedics, Yorba Linda, CA) as described (Fatouros et al., 2005a). Total energy expenditure (TEE) of the exercise session in each phase of the program was estimated by summing a) the aerobic energy expenditure (AEE) during exercise which was estimated using a constant value of 5.05 kcal/liter oxygen (di Prampero & Ferretti, 1999), b) the anaerobic energy expenditure (ANEE) using resting and post-exercise BLA measurements as described (Scott, 2006; di Prampero & Ferretti, 1999), and c) EPOC. BLA was measured using a hand-portable analyzer (Accutrend Plus, Roche

Diagnostics, Basel, Switzerland) as previously described (Baldari et al., 2009). The results of the measurement of exercise-induced caloric expenditure and blood lactate are shown in Table 3.

Measurement of habitual physical activity and estimation of energy balance

Seven-day habitual PA level was determined at baseline, at mid-training and at post-training using an accelerometer (GT3X-BT, ActiGraph, Pensacola, FL, USA) that was secured on subjects' right hip as described (Trost, 2011) and was used as many hours as possible for seven consecutive days in order to capture and record continuous and high resolution physical activity. Additionally, participants were instructed to follow strictly the manufacturer's instructions related to the positioning of accelerometer for use during the 24-hour PA record, except night sleep. The validated 3-axis accelerometer included a digital filtering technology and an integrated wear time and ambient light sensors and was used to record the duration of light, moderate, vigorous, and very vigorous activity, steps per day, and energy expenditure through daily physical activity (Vanhelst et al., 2012). The forces were measured, summed and recorded as counts per time frame and there is a high correlation between accelerometer and indirect calorimetry (NSCA & Miller, 2012). The results of PA assessment are shown in Figure 4.

The duration of inactivity and light, moderate, and vigorous activity as well as steps/day and EE was recorded. Participants were encouraged to maintain their usual daily PA throughout the experimental period. Energy balance during an exercise and a non-exercise day was estimated as calories consumed through daily diet (energy intake) minus calories expended as RMR, EEC and habitual PA (energy expenditure). This relationship is defined by the laws of thermodynamics that dictates that weight is lost, gained, or remains the same (Hall et al., 2012). The estimation of energy balance is shown in Figure 3.

Dietary monitoring

Participants in all groups were asked to follow an isocaloric diet (based on RMR measurements and habitual PA at baseline). A trained dietitian provided instructions on how to adapt to a weight maintenance diet (55-60% carbohydrate, 15-20% protein, 20%-25% fat in the form of nutritional equivalents) during an initial adaptation period (4 weeks) during which body mass was monitored to verify the accuracy of the assigned energy approach (whenever needed it was adjusted accordingly to maintain the target body mass). During intervention, RMR and isocaloric requirements were re-determined. To measure diet composition and caloric intake during the experimental period, participants submitted 7-day diet recalls following training on how to record food and fluid consumption by a registered dietitian. Diet recalls were analyzed using a computerized nutritional analysis software (ScienceTech Diet 200A, Science Technologies, Athens, Greece). Participants were instructed to maintain the same feeding behavior regarding the size and selection of foods and eating habits generally in order to be avoided any unexpected dietary intervention on effectiveness of the exercise training program during the entire study.

Statistical analysis

All data were analyzed using SPSS 24.0. Assumptions of sphericity were tested using Mauchley's test and if violated degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. A two-way [trial (C, TR, and TRD) x time (pre-exercise, mid-exercise, and post-exercise)], repeated measures ANOVA with planned contrasts on different time points was used to determine the effects of treatment and time on dependent variables. Bonferonni test was utilized for post hoc analysis, when a significant main effect was detected. The significance level was set at $P \leq 0.05$. Effect sizes were also calculated and all data are presented as mean ± standard deviation.

Table 1. Exercise protocol of the FFIT program* across all training phases.

	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**
Length (weeks)	7	7	6	20
Duration (min)	23.0	38.0	41.0	41.0
Net exercise time (min)	6.7	16.5	24.0	24.0
Total resting time (min)	16.3	21.5	17.0	17.0
Work-to-rest ratio	1:2	1:1	2:1	2:1
Work interval (sec)	20.0	30.0	40.0	40.0
Rest interval (sec)	40.0	30.0	20.0	20.0
Exercises (stations)	10	11	12	12

*Participants performed as many repetitions as possible in prescribed work time intervals; alternative forms of exercise with similar characteristics were also used in each phase.

Table 2. Prescribed exercises for the FFIT program* across all training phases.

Exercises	Phase 1	Phase 2	Phase 3	Phase 4
1	Over dome ankle touch	Straddle jump	Split jack	Over dome hand touch
2	Row with a neutral grip	Row with a wide grip	Y deltoid raise	Chest press
3	Sumo deadlift	Sumo deadlift & high pull	Sumo deadlift & high pull	Single-arm snatch
4	Plank with straight arms	Forearm plank	Straight arms reverse plank	Side plank rotation
5	Low knee skip	Lateral shuffle	Heel flick	High knee skip
6	Bilateral wave	Alternating wave	Side-to-side wave	Slam
7	Alternate static lunge	Front lunge overhead press	Forward lunge front raise	Twisting chop
8	Forearm plank	Forearm plank & leg lift	Shifting Plank	Forearm plank & leg lift
9	Jumping jack	Split jack	Ice skater	Burpee
10	Squat & overhead press	Lateral shuffle press	Hockey slap shot	Axe chop
11		Single-arm squat & press	Reverse lunge & reverse fly	Band squat & row
12			Medicine ball chest throw	Lunge & overhead press

*Participants performed as many repetitions as possible in prescribed work time intervals; alternative forms of exercise with similar characteristics were also used in each phase.

Table 3. Physiological and metabolic characteristics of the FFIT p across all training phases.

	Phase 1	Phase 2	Phase 3	Phase 4	
Mean HR (beats/min)	118.5 ± 10.3	130.8 ± 10.7[a]	143.2 ± 14.5[b,d]	151.1 ± 11.3[c,e]	Phases 1 vs 2: P=0.042; CI: -1.94/-0.34 ; ES= -1.14
					Phases 1 vs 3: P=0.000; CI: -2.80/-1.01 ; ES= -1.91
					Phases 1 vs 4: P=0.000; CI: -3.99/-1.86 ; ES= -2.93
					Phases 2 vs 3: P=0.011; CI: -1.73/-0.16 ; ES= -0.94
					Phases 2 vs 4: P=0.001; CI: -2.67/-0.91 ; ES= -1.79
Mean HR (% maxHR)	72.5 ± 9.3	79.7 ± 5.1	87.0 ± 3.8[b,d]	87.5 ± 4.7[c,e]	Phases 1 vs 3: P=0.000; CI: -2.89/-1.08 ; ES= -1.98
					Phases 1 vs 4: P=0.001; CI: -2.88/-1.07 ; ES= -1.98
					Phases 2 vs 3: P=0.010; CI: -2.42/-0.73 ; ES= -1.58
					Phases 2 vs 4: P=0.013; CI: -2.39/-0.70 ; ES= -1.54
maxHR (beats/min)	150.7 ± 15.5	157.6 ± 12.3	164.9 ± 12.5[b,d]	172.5 ± 9.9[c,e]	Phases 1 vs 3: P=0.001; CI: -1.76/-0.20 ; ES= -0.98
					Phases 1 vs 4: P=0.001; CI: -2.48/-0.77 ; ES= -1.63
					Phases 2 vs 3: P=0.007; CI: -1.33/0.18 ; ES= -0.57
					Phases 2 vs 4: P=0.007; CI: -2.11/-0.48 ; ES= -1.30

BLa (mM)					
Pre-exercise	1.61 ± 0.39	1.54 ± 0.21	1.36 ± 0.37	1.53 ± 0.40	
Mid-exercise	8.02 ± 0.86	11.57 ± 0.65[a]	12.31 ± 1.63[b]	12.42 ± 1.51[c]	Phases 1 vs 2: P=0.000; CI: -5.92/-3.12 ; ES= -4.52
					Phases 1 vs 3: P=0.000; CI: -4.31/-2.08 ; ES= -3.20
					Phases 1 vs 4: P=0.000; CI: -4.65/-2.30 ; ES= -3.48
Post-exercise	8.99 ± 1.18	11.31 ± 0.53[a]	11.78 ± 1.94[b]	11.99 ± 1.24[c]	Phases 1 vs 2: P=0.000; CI: -3.44/-1.48 ; ES= -2.46
					Phases 1 vs 3: P=0.001; CI: -2.55/-0.82 ; ES= -1.69
					Phases 1 vs 4: P=0.000; CI: -3.38/-1.43 ; ES= -2.41
VE (L/min)	55.71 ± 7.4	62.00 ± 7.7[a]	68.71 ± 6.6[b,d]	73.50 ± 5.5[c,e]	Phases 1 vs 2: P=0.000; CI: -1.58/-0.04 ; ES= -0.81
					Phases 1 vs 3: P=0.000; CI: -2.68/-0.92 ; ES= -1.80
					Phases 1 vs 4: P=0.000; CI: -3.66/-1.63 ; ES= -2.65
					Phases 2 vs 3: P=0.000; CI: -1.69/-0.13 ; ES= -0.91
					Phases 2 vs 4: P=0.001; CI: -2.53/-0.81 ; ES= -1.67

VO_2 (mL/kg/min)	18.05 ± 1.8	19.26 ± 2.0[a]	23.64 ± 2.5[b,d]	23.84 ± 2.4[c,e]	Phases 1 vs 2: P=0.000; CI: -1,38/0,14 ; ES= -0,62
					Phases 1 vs 3: P=0.000; CI: -3,48/-1,50 ; ES= -2,49
					Phases 1 vs 4: P=0.000; CI: -3,66/-1,63 ; ES= -2,65
					Phases 2 vs 3: P=0.000; CI: -2,77/-0,99 ; ES= -1,88
					Phases 2 vs 4: P=0.001; CI: -2,92/-1,10 ; ES= -2,01
RER	1.04 ± 0.07	1.08 ± 0.06[a]	1.10 ± 0.06[b,d]	1.11 ± 0.07[c]	Phases 1 vs 2: P=0.001; CI: -1.35/0.16 ; ES= -0.60
					Phases 1 vs 3: P=0.001; CI: -1.67/-0.12 ; ES= -0.89
					Phases 1 vs 4: P=0.008; CI: -1.75/-0.19 ; ES= -0.97
					Phases 2 vs 3: P=0.036; CI: -1.07/0.42 ; ES= -0.32
METs (MET·hours)	5.16(1.55)±0.5	5.50(2.75)±0.6[a]	6.75(4.05)±0.7[b,d]	6.78(4.07)±0.7[c,e]	Phases 1 vs 2: P=0.000; CI: -1.35/0.16 ; ES= -0.60
					Phases 1 vs 3: P=0.000; CI: -3.53/-1.54 ; ES= -2.54
					Phases 1 vs 4: P=0.000; CI: -3.59/-1.58 ; ES= -2.59
					Phases 2 vs 3: P=0.000; CI: -2.75/-0.97 ; ES= -1.86
					Phases 2 vs 4: P=0.001; CI: -2.80/-1.01 ; ES= -1.91
MET·hours/week	4.65	8.25	12.15	12.21	

RPE	13.71 ± 1.3	14.86 ± 1.2[a]	16.00 ± 0.9[b,d]	16.14 ± 0.5[c,e]	Phases 1 vs 2: P=0.000; CI: -1.67/-0.12 ; ES= -0.89
					Phases 1 vs 3: P=0.000; CI: -2.89/-1.08 ; ES= -1.99
					Phases 1 vs 4: P=0.000; CI: -3.37/-1.42 ; ES= -2.40
					Phases 2 vs 3: P=0.000; CI: -1.83/-0.25 ; ES= -1.04
					Phases 2 vs 4: P=0.024; CI: -2.17/-0.53 ; ES= -2.56
TEE (kcal)	164.9 ± 17.9	306.3 ± 34.8[a]	411.2 ± 45.0[b,d]	385.1 ± 36.2[c,e]	Phases 1 vs 2: P=0.000; CI: -6.46/-3.47 ; ES= -4.96
					Phases 1 vs 3: P=0.000; CI: -8.96/-5.01 ; ES= -6.98
					Phases 1 vs 4: P=0.000; CI: -9.58/-5.39 ; ES= -7.49
					Phases 2 vs 3: P=0.000; CI: -3.53/-1.54 ; ES= -2.53
					Phases 2 vs 4: P=0.000; CI: -3.09/-1.22 ; ES= -2.15
AEE	133.2 ± 17.4	276.9 ± 33.1[a]	348.3 ± 43.1[b,d]	322.9 ± 34.1[c,e]	Phases 1 vs 2: P=0.000; CI: -6.84/-3.71 ; ES= -5.28
					Phases 1 vs 3: P=0.000; CI: -8.18/-4.53 ; ES= -6.35
					Phases 1 vs 4: P=0.000; CI: -8.73/-4.87 ; ES= -6.80
					Phases 2 vs 3: P=0.000; CI: -2.68/-0.93 ; ES= -1.80
					Phases 2 vs 4: P=0.017; CI: -2.15/-0.51 ; ES= -1.33

ANEE	20.7 ± 2.8	27.0 ± 4.2[a]	28.3 ± 3.4[b]	26.9 ± 3.8[c]	Phases 1 vs 2: P=0.030; CI: -2.58/-0.85 ; ES= -1.71
					Phases 1 vs 3: P=0.000; CI: -3.34/-1.40 ; ES= -2.37
					Phases 1 vs 4: P=0.000; CI: -2.68/-0.92 ; ES= -1.80
EPOC	11.0 ± 3.4	26.1 ± 5.7[a]	34.7 ± 3.5[b,d]	35.3 ± 3.8[c,e]	Phases 1 vs 2: P=0.000; CI: -4.23/-2.02 ; ES= -3.12
					Phases 1 vs 3: P=0.000; CI: -8.57/-4.77 ; ES= -6.67
					Phases 1 vs 4: P=0.000; CI: -8.41/-4.68 ; ES= -6.54
					Phases 2 vs 3: P=0.000; CI: -2.64/-0.89 ; ES= -1.77
					Phases 2 vs 4: P=0.001; CI: -2.73/-0.96 ; ES= -1.84

HR, heart rate; maxHR, maximal heart rate; BLa, mean blood lactate concentration; VE, mean minute ventilation; VO2, mean oxygen consumption; RER, respiratory exchange ration; METs, metabolic equivalent of task; RPE, rates of perceived exertion; TEE, total energy expenditure; AEE, aerobic energy expenditure; ANEE, anaerobic energy expenditure; EPOC, excess post-exercise oxygen consumption; CI, confidence intervals; ES, effect size; [a]denotes a difference between phases 1 and 2 at P<0.05 or at P<0.1; [b]denotes a difference between phases 1 and 3 at P<0.05 or at P<0.1; [c]denotes a difference between phases 1 and 4 at P<0.05 or at P<0.1; [d]denotes a difference between phases 2 and 3 at P<0.05 or at P<0.1; [e]denotes a difference between phases 2 and 4 at P<0.05 or at P<0.1; [f]denotes a difference between phases 3 and 4 at P<0.05 or at P<0.1.

Table 4. Changes of habitual physical activity and energy intake during the experimental period.

	Pre-training			Mid-Training			Post-Training/Detraining		
	C	**TR**	**TRD**	**C**	**TR**	**TRD**	**C**	**TR**	**TRD**
Habitual PA									
Sedentary PA (min)	1201.5±88.4	1200.3±75.2	1203.8±80.1	1199.3±108.8	1200.7±70.9	1195.5±80.1	1200.8±232.1	1206.6±74.5	1202.1±83.1
Light PA (min)	198.5±78.1	194.1±74.9	191.8±66.5	199.0±101.9	195.9±71.3	201.6±69.4	203.2±89.4	196.0±72.2	193.6±63.5
Moderate PA (min)	42.9±13.1	44.6±8.8	42.4±20.7	43.9±12.1	41.4±9.1	40.7±18.7	34.9±12.5	35.1±7.8	38.5±19.5
Vigorous PA (min)	1.05±0.8	0.98±1.8	0.91±1.5	0.94±0.7	1.29±1.9	1.21±1.5	1.02±0.8	1.51±1.7	1.19±1.3
MVPA (min)	43.9±13.6	45.6±9.7	43.3±21.2	44.8±12.6	42.7±9.9	41.9±19.2	35.9±13.2	36.6±8.5	39.7±19.8
Steps/day	5,995.7± 1,346.9	6,166.4± 1,041.5	6,275.8± 1,445.7	5,984.7± 1,332.7	6,163.9± 1,092.5	6,355.1± 1,431.0	5,993.9± 1,439.7	6,322.5± 1,004.2	6,241.4± 1,450.2
Kcal/day	182.2±73.6	170.9±60.0	276.1±88.6	180.3±70.6	177.9±58.3	168.4±84.8	173.5±71.3	185.4±60.0	171.2±67.5
Energy intake (kcal/day)	1829.9±193.9	1840.5±151.8	1839.6±230.8	1831.4±178.0	1823.4±163.3	1819.4±231.5	1834.1±158.0	1815.9±150.2	1827.2±201.3

C, control group; TR, trained group; TRD, trained-detrained group PA, physical activity; MVPA, moderate-to-vigorous physical activity; METs, metabolic equivalent of task; [a]denotes a difference between baseline and mid-training at $P<0.05$ or at $P<0.1$; [b]denotes a difference between mid-training and post-training or detraining at $P<0.05$ or at $P<0.1$; [c]denotes a difference between baseline and post-training or detraining at $P<0.05$ or at $P<0.1$.

Table 5. Changes of anthropometrics and resting metabolic rate during the experimental period.

	Pre-training			Mid-Training			Post-Training/Detraining		
	C	**TR**	**TRD**	**C**	**TR**	**TRD**	**C**	**TR**	**TRD**
RMR (kcal/day)	1501.1±162.8	1451.6±145.4	1504.1±220.3	1507.6±150.9	1536.4±158.1[a]	1637.9±163.6[a]	1523.7±141.8	1597.9±160.9[,c]	1524.9±170.[b]
Body mass (kg)	80.2±8.9	78.4±9.9	78.2±7.8	80.4±7.7	74.2±10.2[a]	75.5±8.2[a]	80.9±7.7	73.4±10.0[c]	76.7±9.0[b]
Body height (m)	1.65±0.05	1.66±0.05	1.64±0.06	1.65±0.05	1.66±0.05	1.64±0.06	1.65±0.05	1.66±0.05	1.64±0.06
BMI (kg/m^2)	29.5±2.9	28.4±2.8	29.1±3.0	29.5±2.7	26.9±2.9[a]	28.1±3.4[a]	29.7±2.6	26.6±2.7[c]	28.5±3.5[b]
Body fat (%)	46.7±6.5	47.5±3.2	46.2±3.9	47.1±6.5	43.9±4.1[a]	43.9±5.5[a]	47.7±6.5[b,c]	42.0±4.5[b,c]	44.7±5.1[b,c]
Fat mass (kg)	37.4±8.3	37.2±6.6	36.1±6.0	37.9±7.5	32.5±7.1[a]	33.1±7.0[a]	38.5±7.9 [b,c]	30.8±6.9[b,c]	34.3±7.3[b,c]
FFM (kg)	42.8±7.2	41.2±4.2	42.1±3.2	42.5±6.7	41.7±4.3[a]	42.4±3.4[a]	42.4±6.6	42.6±4.5[b,c]	42.4±3.6[b,c]
WCR (cm)	95.9±5.3	96.7±8.8	96.4±8.9	96.1±4.8	90.8±8.2[a]	89.3±9.0[a]	97.6±5.1[b]	90.1±8.7[c]	94.0±10.0[b,c]
HCR (cm)	110.3±6.5	110.9±6.5	110.9±7.2	111.0±6.1	108.0±7.6[a]	108.8±7.9[a]	112.2±5.6[b,c]	107.9±7.1[c]	110.0±7.1[b]
WHR	0.87±0.03	0.87±0.04	0.87±0.06	0.87±0.04	0.84±0.04[a]	0.82±0.07[a]	0.87±0.04	0.83±0.05[c]	0.85±0.07[b]

C, control group; TR, trained group; TRD, trained-detrained group; RMR, resting metabolic rate; BMI, body mass index; FFM, fat-free mass; WCR, waist circumference; HCR, hip circumference; WHR, waist-to-hip ratio; [a]denotes a difference between baseline and mid-training at $P<0.05$ or at $P<0.1$; [b]denotes a difference between mid-training and post-training or detraining at $P<0.05$ or at $P<0.1$; [c]denotes a difference between baseline and post-training or detraining at $P<0.05$ or at $P<0.1$.

RESULTS

A 94% compliance and a zero drop-out rate was achieved. Participants from all groups demonstrated comparable physical, performance and metabolic characteristics at baseline. Participants in all groups could be characterized as completely inactive since their MVPA time was just ≤0.5 h/week and they had very low step count/day (<7,500) and VO_{2max} values. No differences were detected in diet intake across time and among groups (data not shown).

Training data are illustrated in Table 2. Mean training HR was similar in TR and TRD throughout the intervention period (pre- to mid-training). Mean training HR increased (P=0.000-0.042) progressively from phase 1 through phase 3 with phase 4 exhibiting the same mean value with phase 3. Mean training HR, (expressed as a percentage of maximal HR that was obtained during the GXT) and maximal training HR had a tendency to increase from phase 1 to phase 2 and then increased progressively from phase 2 to phase 3 (P=0.007) but not in phase 4. BLA exhibited a progressive rise (P=0.000) during a training session in all phases. Resting BLA values were similar across all training phases. BLA measured at mid- and post-exercise was of lower magnitude in phase 1 compared to the other phases (P=0.000 – 0.001) but there were no differences between phases 2, 3 and 4. Mean minute ventilation, VO_2, RER, METs, RPE, TEE (in kcal/min and in kcal) during an exercise session increased (P=0.000-0.036) progressively from phase 1 through phase 4 (P=0.000).

Performance results are shown in Figure 2. In C, VO_{2max} remained unchanged at 20 weeks compared to baseline but it declined at 40 weeks (P=0.013; CI=-0.43/0.79; ES=0.18). In TR, VO_{2max} increased at mid-training (P=0.000; CI=-2.01/-0.40; ES=-1.20) and increased further at post-training (P=0.000; CI=-1.00/0.49; ES=-0.26). In TRD, VO_{2max} increased at mid-training (P=0.000; CI=-2.01/-0.40; ES=-1.20) and decreased thereafter (P=0.000; CI=-0.15/1.37; ES=0.61) but remained above baseline levels (P=0.000; CI=-1.37/0.15; ES=-

0.61). At mid-training, VO_{2max} demonstrated similar values in TR and TRD and they were both higher than C (C vs. TR: P=0.000; CI=-2.26/-0.74; ES=-1.50; C vs. TRD: P=0.000; CI=-2.50/-0.93; ES=-1.71). At 40 weeks, TR demonstrated higher VO_{2max} values than C and TRD (TR vs. C: P=0,000; CI=1.08/2.70; ES=1.89; TR vs. TRD: P=0.041; CI=0.08/1.62; ES=0.85) and TRD than C (P=0.012; CI=0.46/1.92; ES=1.19). Maximal lower body 1RM in C remained unchanged throughout the experimental period. In TR, 1RM increased at mid-training (P=0.000; CI=-1.53/0.00; ES=-0.77) and increased further at post-training (P=0.000; CI=-1.24/0.26; ES=-0.49). In TRD, 1RM increased at mid-training (P=0.000; CI=-1.52/0.07; ES= -0.73) and decreased thereafter but remained above baseline levels (P=0.000; CI=-0.10/1.48; ES=0.69).

Table 3 presents changes in somatometric variables, RMR, habitual PA, and dietary intake. Habitual PA and daily energy intake were similar in all groups and no changes were observed throughout the experimental period. RMR remained unaffected in C, in TR it increased (mid training: P=0.046; CI=-1.30/0.21; ES= -0.54; post-training: P=0.012; CI=-1.12/0.37; ES= -0.37) progressively throughout the experimental period whereas in TRD it increased at mid-training (P=0.001; CI=-1.43/0.09; ES= -0.67) and remained above baseline (P=0.000; CI=-0.10/1.42; ES=0.66) at 40 weeks. Body mass and BMI remained constant in C, in TR they decreased at mid-training (body mass: P=0.000; CI=-0.38/1.12, ES=0.37; BMI: P=0.000; CI=-0.28/1.23, ES=0.48) and demonstrated a trend for further reduction at post-training (body mass: P=0.092; CI=-0.67/0.82; ES=0.08; BMI: P=0.086; CI=-0.64/0.84; ES=0.10) whereas in TRD they decreased at mid-training (body mass: P=0.000; CI=-0.42/1.08; ES=0.33; BMI: P=0.000; CI=-0.44/1.05; ES=0.30) but increased following detraining (body mass: P=0.003; CI=-0.88/0.60, ES=-0.14; BMI: P=0.004; CI=-0.87/0.62; ES=-0.12) without reaching pre-training levels. Body fat increased in C during the study (post- vs. pre-training: P=0.008; CI=-0.76/0.45, ES=-0.15) but in TR and TRD it declined both at mid- (TR: P=0.000; CI=0.28/1.87, ES=1.08; TRD: P=0.000; CI=-0.27/1.24, ES=0.49) and post-training (TR: P=0.000; CI=-0.44/1.05, ES=0.30; TRD: P=0.000; CI=-0.92/0.57, ES=-0.17). On the other hand, fat-free mass (FFM) remained unchanged in C but it increased both at mid- (TR: P=0.001; CI=-1.07/0.42, ES=-0.32; TRD: P=0.015; CI=-1.06/0.43, ES=-0.32) and post-intervention (TR: P=0.000; CI=-1.20/0.30, ES=-0.45; TRD: P=0.000; CI=-1.04/0.45, ES=-0.29) in the other two groups. WC in C exhibited a tendency to increase (P=0.059; CI=-0.93/0.29; ES=-0.32) at the end of the study, in TR it decreased at mid-training (P=0.000; CI=-0.09/1.44; ES=0.68) and remained above baseline at post-training (P=0.000; CI=-0.03/1.50; ES=0.74) and in TRD it decreased at mid-training (P=0.000; CI=0.000/1.53; ES=0.77) and increased (P=0.000; CI=-1.23/0.27; ES=-0.48) at post-intervention without reaching pre-training values (P=0.028; CI=-0.50/0.99; ES=0.24). HC increased at the end of the study in C (P=0.012; CI=-0.92/0.30; ES=-0.31) whereas in TR it decreased at mid-training (P=0.002; CI=-0.35/1.15; ES=0.40) and remained above baseline levels at post-training (P=0.001; CI=-0.31/1.19; ES=0.44) and in TRD it decreased at mid-training (P=0.031; CI=-0.47/1.01; ES=0.27) and increased thereafter (P=0.015; CI=-0.90/0.59; ES=-0.16) without reaching pre-training values. WHR remained unchanged in C, in TR it decreased at mid-training (P=0.002; CI=-0.04/1.49; ES=0.73) and remained above baseline levels thereafter (P=0.000; CI=0.08/1.63; ES=0.86) whereas in TRD it decreased at mid-training (P=0.000; CI=-0.02/1.51; ES=0.74) and increased following detraining (P=0.000; CI=-1.16/0.33; ES=-0.42) without reaching pre-training values.

Figure 3 provides a schematic representation of energy balance at baseline, at mid-training and at post-training or detraining for both exercise and non-exercise days (values are based on food kcal for energy intake and on the sum of kcal for RMR, habitual PA and exercise for energy expenditure. It appears that exercise augments the energy expenditure values thus contributing to an increased overall energy deficit on a weekly basis.

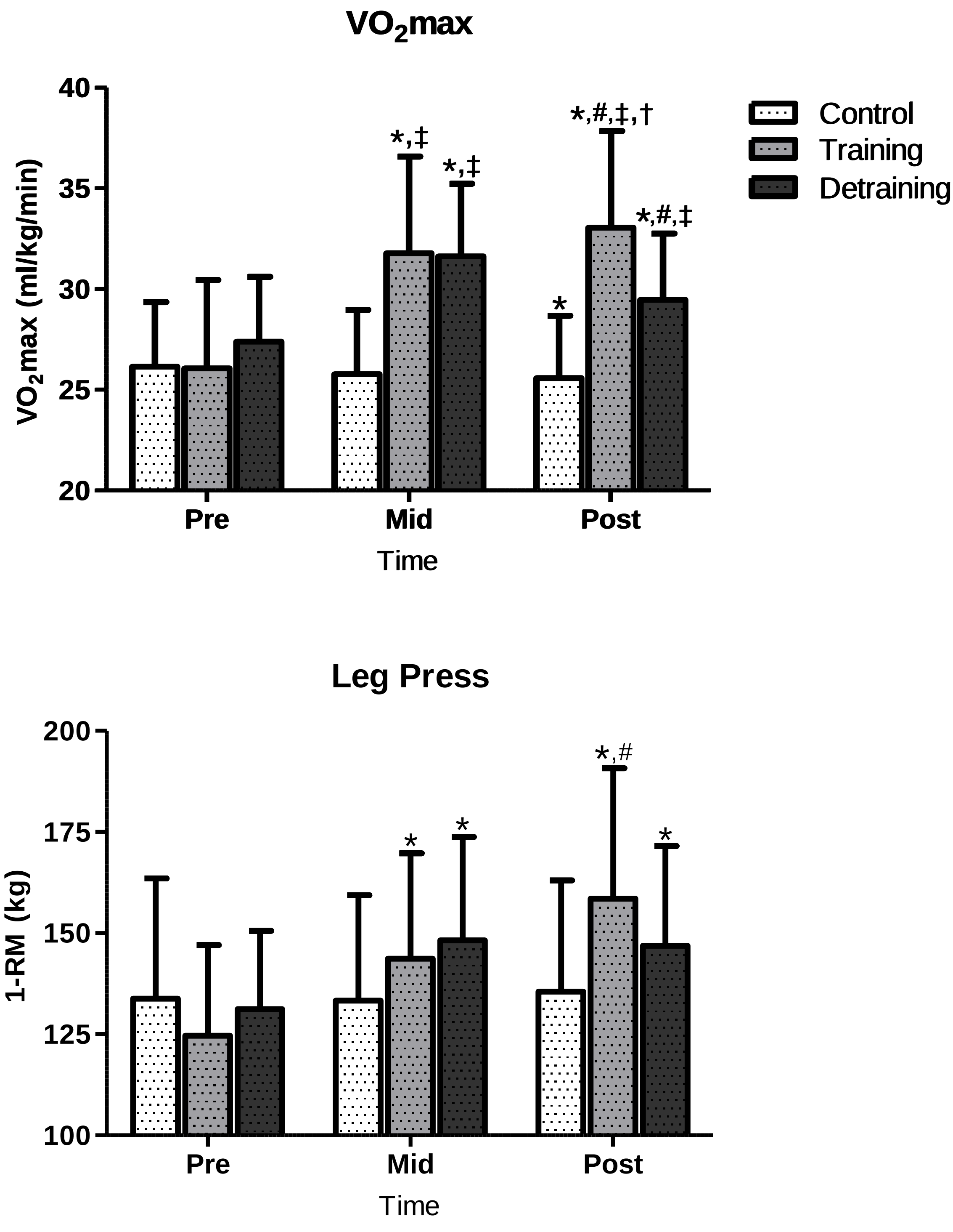

Figure 2. Performance changes during the experimental period.

VO_{2max}, maximal oxygen consumption; *significant difference with baseline ($P<0.05$); ‡ significant difference with the control group ($P<0.05$); # significant difference with previous time point ($P<0.05$); † significant difference between training and training-detraining groups ($P<0.05$).

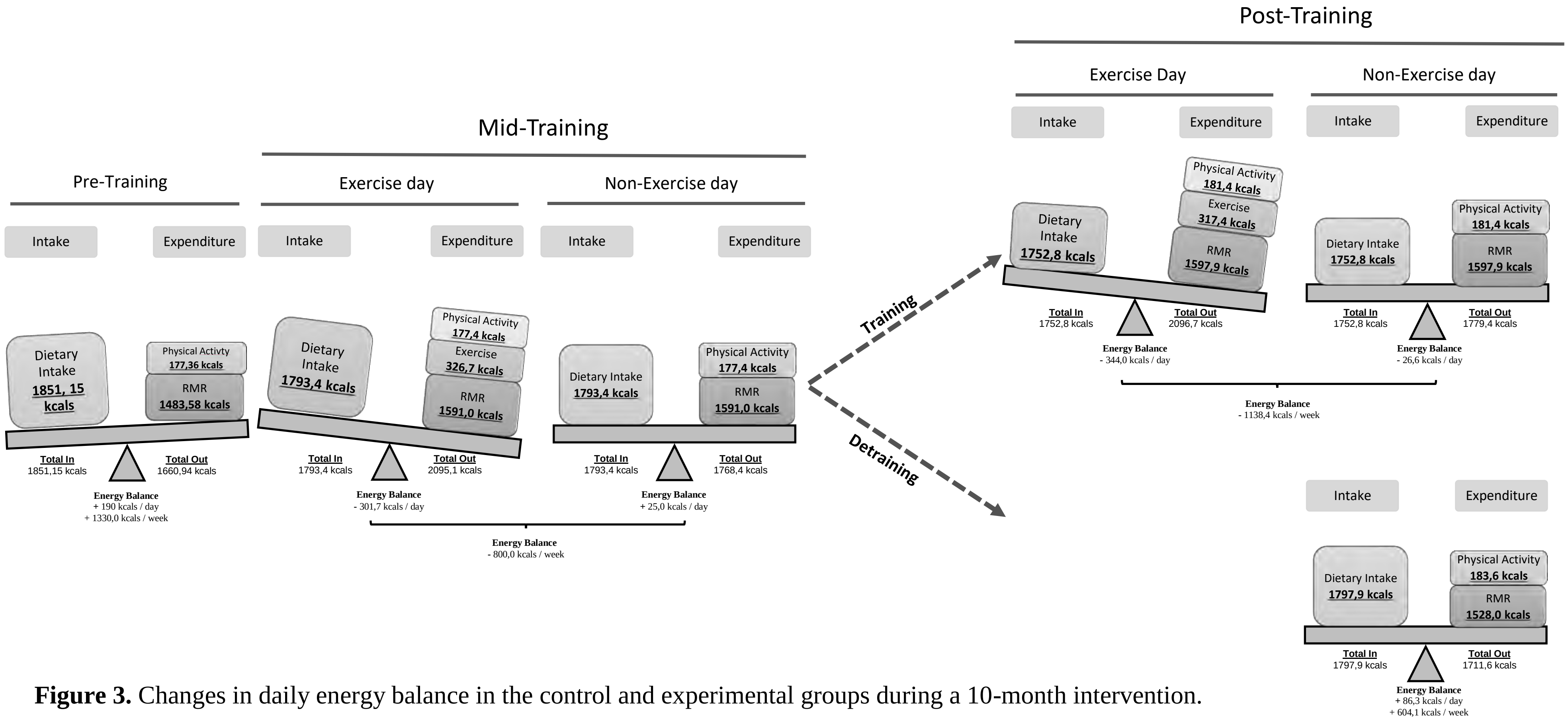

Figure 3. Changes in daily energy balance in the control and experimental groups during a 10-month intervention.

RMR, resting metabolic rate.

DISCUSSION

The main findings of this study revealed that a 10-month implementation of the novel FFIT small-group, hybrid program resulted in i) enhanced daily EE over energy intake thereby reducing body and fat mass; ii) increased strength and cardiovascular performance; and iii) demonstrated an exceptionally high adherence rate. Training-induced gains were attenuated but not lost following a 5-month detraining period.

Changes in body mass and body composition

In developed countries, 42-51% of Caucasian women aged 20-40 years that consisted our sample are classified as overweight or obese (WHO, 2014). It is estimated that women may gain as much as 6-12 kg during the first two decades of their adulthood (Lucke et al., 2007), more than any other population group (Lucke et al., 2007). During the same time, 85% of women aged 18-40 years demonstrate increased inactivity levels (Cleland et al., 2011). Inactivity and weight gain predispose women of this age to metabolic syndrome, type 2 diabetes, infertility, depression and other pathologies (Emaus et al., 2008).

FFIT resulted in marked changes of participants' anthropometric profile. FFIT induced a ~4-5% (-3-4 kg) weight reduction at 5 months and ~6% (-4.6 kg) following 10 months of training. These results agree with findings of a recent meta-analysis suggesting that long-term HIIT protocols could favorably affect the somatometric profile of overweight individuals (Batacan, Duncan, Dalbo, Tucker, & Fenning, 2017). Our findings are in line with previous reports that suggested only modest (<5 kg) body mass loss when exercise is used exclusively as a weight management intervention (Shaw eet al., 2006). CET alone may induce a mean weight loss of ~3 kg following 4 months (Vanhees et al., 2011) whereas a dose of 13-26 MET-hours/week of continuous endurance training are required to obtain a weight loss of ≥1-3% (Wasfy & Baggish, 2016). Although FFIT's metabolic overload ranged from ~5 to 12 MET-hours/week, it induced a 4-6% weight loss, which is greater than that (3%) induced by high-volume (27 km/week) CET alone (Slentz et al., 2005). These results corroborate that high-intensity protocols are more effective than low-intensity protocols for weight loss and may be equally or more effective than traditional exercise protocols utilizing a lower weekly total exercise dose. Weight losses of >5% (>8 kg at 12 months) are usually seen in response to a combination treatment of diet and exercise or CET of high energy expenditure (≥26 MET-hours/week) (Jensen et al., 2014; Wasfy & Baggish, 2016). Collectively, these results are important since, sustained body mass loss of 3%–5% has been associated with clinically meaningful decline in lipids, sugar, and glycosylated hemoglobin A1c in the blood and with reduced risk for developing cardiovascular disease and type 2 diabetes (Jensen et al., 2014).

FFIT impact is in line with the guidelines issued by the American Heart Association (AHA) that suggest an initial weight loss of 5%-10% of baseline weight within 6 months (Jensen et al., 2014). Most weight loss candidates usually equilibrate after 6 months (energy intake matches energy expenditure) and thus they demonstrate a plateau and likely a gradual regain over time (Jensen et al., 2014). It is characteristic that FFIT induced a gradual weight loss over a 10-month period probably due to readjustment of energy balance. This outcome is of great significance since among overweight/obese adults who participate in an intensive and comprehensive prolonged lifestyle intervention, only 35%-60% of them exhibit a sustained weight loss of ≥5% at ≥2 years from the beginning of the intervention.

FFIT also decreased body fat by 4.1% and 5.5% and increased FFM by 1.2% and 3.4% following 5 and 10 months of training, respectively. The magnitude of body fat reduction agrees with previous tri-weekly endurance exercise protocols of shorter duration (4 months) (Vanhees et al., 2011). It appears that HIIT protocols may be equally effective with CET protocols in reducing fat mass (2.2-2.5%) when applied for 3 months (Schjerve et al., 2008) whereas longer protocols may induce even greater fat mass reductions (Hansen, Dendale, van Loon, & Meeusen, R., 2010). In fact, only 6 weeks of interval speed training reduced total and android fat in overweight young women (Higgins, Fedewa, Hathaway, Schmidt, & Evans, 2016). This is in accordance with results of this study that caused a 5.5% decline of fat mass in 10 months. Although it is questionable whether the addition of RE to traditional CET protocols are effective in further reducing fat mass (Vanhees et al., 2011), FFIT, a hybrid HIIT protocol that combines the two, was able to cause substantial fat mass loss. This fat decline induced by exercise without modifying energy intake may be attributed to a reduction of visceral and subcutaneous abdominal fat and is probably dose-dependent (Slentz et al., 2005). Visceral fat reduction in overweight/obese adults without metabolic dysfunctions has been linked with an exercise dose approaching 10 MET-hours/week, a value obtained by FFIT (Strasser & Schobersberger, 2012). The increase in FFM may be attributed to the RE component of FFIT which has been shown to effectively upregulate FFM of obese individuals (Vanhees et al., 2011).

WC and HC declined by 5.9 cm (-6%) and 3 cm (-2.6%), respectively, following 5 months of training. At post-training, WC reached a decline of 6.6 cm (-6.8%) whereas HC exhibited no further decline. Thus, WHR decreased by 3.4% and 4.6% at mid- and post-training, respectively. This is clinically significant finding since risk factors increase proportionately with WC (Jensen et al., 2014). Similar results (7 cm loss at waist) were obtained in overweight/obese cardiac patients following 5 months of high-calorie-expenditure exercise (Ades et al., 2009).

At the same time, controls gained 0.7 kg, increased their body fat by 1%, their fat mass by 1.2 kg, their WC by 1.7 cm, and their HC by 1.9 cm but they decreased their FFM by 0.5

kg. In line with our findings, 6 months of inactivity of overweight adults resulted in considerable rise of visceral fat (8.6%) which was prevented by exercise (Slentz et al., 2005).

Mechanisms

Exercise-induced weight loss represents a deficit between total daily energy intake and energy expenditure, thus creating a negative net energy balance (Thomas et al., 2012). EE depends upon RMR, physical activity-induced caloric expenditure, energy cost of digestion and metabolism, and thermogenesis (Manore et al., 2014). In this study, we aimed to increase daily energy expenditure through the implementation of FFIT without changing energy intake. Exercise-induced weight loss is associated with an increase in exercise-related energy expenditure, a rise in RMR and a reduction of fat mass (Thomas et al., 2012). However, weight loss in response to exercise may be lower than that expected mainly because exercise produces only small amounts of energy expenditure and may be associated with a concomitant rise of energy caloric intake and a decline of non-exercise PA (Thomas et al., 2012).

Resistance and endurance exercise training act on cytokine signaling thereby causing downstream modifications in non-muscle tissues such the adipose tissue manifested as "browning" which ultimately results in increased thermogenesis and lipolytic activity that further decrease body fat (Clark & Goon, 2015). Since we were unable to measure the energy cost of thermogenesis and that of digestion and metabolism (≤10%), we attempted to estimate participant's energy balance based on EE associated with RMR and movement (exercise and habitual PA, i.e. ~90% of total daily energy expenditure) vs. energy intake based on calories consumed daily as they were assessed using daily diet recalls (Figure 3).

The energy cost of an exercise training program is associated with its intensity and/or volume while participants' gender, age and training status may play a crucial role in terms of the estimation of EE during a specific workout routine (ACSM, 2014). FFIT induced a considerable energy expenditure/session ranging from ~165 kcal in phase 1 to >400 kcal in phases 3 and 4, as measured using a portable O_2/CO_2 analyzer. These numbers are well over those produced by sprint interval training with 30-s sprints (175 kcal/session) and circuit RE (~300 kcal/session) and of the same level (440 kcal/session) with those reported for traditional CET (70% VO_{2max}, 30 min/session) in obese adults (Chatzinikolaou et al., 2008; Hazell et al., 2014; Fatouros et al., 2005a). The energy cost of longer (40-50 min) RE only interval-type protocols using moderate or low weights were ~400 and ~200 kcal/session, respectively suggesting that inclusion of only RE-type exercises induces smaller EE (Beckham & Earnestt, 2000; Reis, Júnior, Zajac, & Oliveira1, 2011; Stanforth., Stanforth, & Hoemeke, 1998).

Collectively, these findings suggest that when combining low-intensity endurance- and resistance-type whole-body exercises, EE is maximized in a time-efficient manner. Interval-type protocols have been shown to upregulate adipose tissue lipolysis and elevate post-exercise oxygen consumption and as such contributing to an increased fat loss (Batacan et al, 2017; Chatzinikolaou et al., 2008). In fact, increased intensity, as in FFIT, is associated with increased EE and fat oxidation immediately post-exercise (Warren, Howden, Williams, Fell, & Johnson, 2009). The increased energy cost of FFIT may explain the immediate effects of this program on total daily EE on exercise day. On a non-exercise day, however, movement energy cost could be attributed solely to energy spent for PA. To account for EE induced by habitual PA, we used accelerometry to monitor time spent on various levels of PA during the day (assuming that these devices are sensitive enough to detect such changes). It appears that daily habitual PA associated EE remained unchanged throughout the interventional period (Figure 3).

FFIT induced a 6% and 10% rise of RMR at 20 and 40 weeks of training, respectively. In cases of weight loss under conditions of increased CET dosage and isocaloric feeding, RMR usually declines by as much as 7%, especially in individuals with reduced FFM such as the obese, and thus the energy deficit induced by exercise may be compromised (Thomas et al., 2012). This adaptation was not seen in this study probably due to the increase in FFM which elevates RMR (Clark & Goon, 2015). Although some data indicate that exercise training may induce FFM loss, others disagree (Thomas et al., 2012). Moreover, when weight loss via CET and/or diet is combined with RE training, FFM is maintained if not increased (Clark & Goon, 2015; Strasser & Schobersberger, 2012). An increase in FFM and in maximal strength (~24%) that was also seen in response to FFIT, probably due to the RE component of this program, gives further support to this notion. HIIT activates more type II muscle fibers thereby resulting in a greater rate of an increase in muscle mass compared to CET (Krustrup, Söderlund, Mohr, González-Alonso, & Bangsbo, 2004). The increase of skeletal muscle sarcoplasmic reticulum calcium uptake by HIIT-type programs supports intense muscle contractions and further explains the marked increase of maximal strength induced by FFIT (Schjerve et al., 2008). The upregulation of FFM could drives the rise of RMR that was seen in response to FFIT. In some cases, an increase in muscle mass may be responsible for the absence of body mass loss despite a decline in body fat. However, this was not the case here since body fat loss coincided with weight loss.

An increase in RMR may also be associated with positive metabolic adaptations mainly at the mitochondrial level. HIIT-type programs, even of short duration, have been reported to upregulate the transcription factor, peroxisome proliferator-activated receptor g-coactivator-1a (PGC-1a), that regulates muscle's oxidative phenotype, in obese patients (Schjerve et al., 2008). An elevation in PGC-1a stimulates mitochondrial biogenesis and glucose transport which could explain the rise in RMR with FFIT (Schjerve et al., 2008).

Indicative of adaptations at the mitochondria level is the marked increase (~24%) of VO_{2max} by FFIT, a response usually seen after implementation of both short- and long-term HIIT programs in overweight/obese adults (Batacan et al., 2017). The increase in VO_{2max} by HIIT is related to the upregulation of skeletal muscle mitochondrial density/size and diffusing capacity as well as to cardiovascular adaptations (e.g. increased stroke volume, cardiac contractility, cardiac output, improved endothelial function due to increased nitric oxide availability) by this type of programs (Batacan et al., 2017; Kessler, Sisson, & Short, 2012). It appears that FFIT elicits similar adaptations in endurance capacity to those usually seen with HIIT-type programs (Kessler et al., 2012). An EPOC increase both immediately post-exercise and during the remainder of the exercise day as well as during the non-exercise day could also explain the increased RMR induced by HIIT-type programs (Kelly et al., 2013; LaForgia, Withers & Gore, 2006). It is well-established that muscle damage and its associated inflammatory response induced by intense exercise may upregulate catabolic and anabolic intracellular cascades to repair damaged muscle fibers (Fatouros & Jamurtas, 2016) and this may contribute to a rise in EPOC and resting EE.

On the other hand, daily energy intake remained unchanged, and despite the limitations of methods used to estimate free living energy intake, a daily energy deficit might have been induced by FFIT (Figure 3). It has been estimated, based on energy intake, RMR, habitual PA and exercise energy cost values that after 5 months of training, a deficit of ~300 kcal on an exercise day was produced by FFIT whereas on a non-exercise day there was a small caloric surplus of 25 kcal/day which by far exceeds that estimated at baseline (190 kcal/day). On a weekly basis, this is translated to a deficit of 800 kcal for the experimental group whereas the controls may store 1,330 kcal at the same time. In 20 weeks of intervention, this is further translated to a deficit of 16,000 kcal (or roughly a loss of 2.2 kg of fat) for the experimental group and a surplus of 26,600 kcal (or roughly a gain of 3.8 kg of fat) for the control group. Due, mainly, to a further rise in RMR the TR group further increased its daily caloric deficit at -344 kcal on the exercise day and -26.6 kcal on a non-exercise day and as such the weekly deficit was 1138.4 kcal which translates to a loss of 22,768 kcal (or roughly a loss of 3.2 kg of fat) during the second 20 weeks of the FFIT intervention and a total deficit of -38,768 (or roughly a loss of 5.5 kg of fat, i.e. 0.1 kg/week) during the 10-month training period. The fat mass loss measured by DXA was ~6 kg which is close to our energy deficit estimations. Fat mass loss could also explain the observed decline in weight loss and changes in body composition in response to FFIT. Long-term intense exercise has been show to elicit substantial loss of visceral fat in obese women (Ross et al., 2000; Irwin et al., 2003). Increased lipolysis and fat oxidation, especially in visceral fat, in response to HIIT-type programs may be attributed to a catecholamine rise (and likely growth hormone) as evidenced by β3-adrenergic receptor blockade following exercise (Batacan et al., 2017; Vincent et al., 2004). Exercise-induced decrease in post-exercise appetite has also been implicated for fat loss with HIIT programs (Williams et al., 2013) but it is uncertain if this is translated to reduced energy intake. Furthermore, body and fat mass loss is positively correlated with an increase in endurance capacity as it was also seen in this study (Ross & Katzmarzyk, 2003).

Detraining

A 5-month detraining resulted in a regain of body (1.7% or 1.3 kg) and fat mass (3.7% or 1.3 kg) whereas FFM declined by 2.4% (1 kg) without reaching pre-training values. These results may be explained by the estimated energy balance (Figure 3) that indicates a surplus of 86.3 kcal/day (or 604 kcal/week and 12,082 kcal for 20 weeks) which may be translated to a regain of 1.7 kg of fat mass during this time. This change in caloric balance may be attributed to the reduced energy spent for RMR and daily movement. During the same period, maximal strength remained unchanged while VO_{2max} decreased by ~7%. It is very difficult to find such a long period of detraining in the literature. In line with our results, when resistance trained (6 months) older adults were subjected to a 6-month detraining demonstrated a regain of body mass and fat without reaching pre-training levels (Fatouros, et al., 2005b). However, when overweight/obese adults were subjected to a 4-week detraining after 12 weeks of interval training, body mass remained unchanged while body fat increased by 0.7% (Nikseresht, Sadeghifard, Agha-Alinejad, & Ebrahim, 2014; Slentz et al., 2005). The small magnitude of body mass and fat losses with detraining may be attributed to the modest reduction of RMR (Fatouros et al., 2005a) due to losses in FFM and exercise-induced metabolic adaptations (Mora-Rodriguez et al., 2014) as also evidenced by the decline of VO_{2max} in this study and others (Nikseresht et al., 2014), decreased lipolysis in visceral fat (Bae et al., 2017), and an elevated glucose uptake by adipose tissue that increases the available substrate for triacylglycerol synthesis (Sertié, Andreotti, Proença, Campaña, & Lima, 2017). In fact, animal studies have shown that previously trained rats when subjected to detraining they demonstrate a higher tendency to develop adiposity in response to a high-fat diet compared to inactive sedentary rats (Yasari, Dufresne, Prudhomme, & Lavoie, 2007).

Training characteristics

It has become apparent that high-intensity exercise is more effective in reducing body mass and fat (Shaw et al., 2006). HIIT incorporates brief high-intensity (85-250% of VO_{2max}; 6 s to 5 min) work intervals of endurance type exercises (e.g. running) separated by short (10 s to 5 min) intervals of rest or low-intensity (20-40% of VO_{2max}) work in repeated sequences (Helgerud et al., 2007). On the other hand, circuit RE utilizes complex exercises engaging a large number of muscle groups simultaneously by adapting a high number of repetitions per station and a lower intensity (40-70% 1RM) compared to traditional RE protocols with a very brief (or no) passive or active rest between work stations (Clark & Goon, 2015). This type of training may induce positive adaptations in cardiorespiratory endurance, preservation of FFM and caloric expenditure and as such it could be used to treat overfat adults (Clark & Goon, 2015). HIIT and RE, although they effectively improve cardiovascular and metabolic conditioning, they may lead to high attrition rates among overweight adults due to their exhaustive nature (Helgerud et al., 2007). We developed a novel hybrid type of HIIT using exercise stations of both endurance and functional whole-body RE (bodyweight exercises, calisthenics, plyometrics, etc.) in circuit fashion using alternative portable equipment to combine the benefits of endurance and RE utilizing the HIIT model. Combining endurance- and RE-type training has been reported to be more effective in reducing visceral fat and increasing FFM compared to CET alone (Strasser & Schobersberger, 2012).

Moreover, the addition of RE prevents regain of fat lost and maintains metabolic adaptations (e.g. insulin sensitivity) induced by endurance exercise (Strasser & Schobersberger, 2012). This type of HIIT protocols seems to elicit similar anthropometric and metabolic adaptations in overweight/obese women with those obtained by traditional CET and RE protocols but with a lower non-respondent rate and a weekly time commitment that is ~30% lower than that required for the minimal recommendations for PA according to current guidelines (Álvarez et al., 2017; Colberg et al., 2010). FFIT was performed according to a group-exercise format in a commercial fitness facility in an attempt to reduce attrition and enhance compliance. Small-group training has emerged as a promising trend in the fitness industry world-wide because it is appealing to clients and time- and cost-effective (Thompson, 2016). However, there is no data on the effectiveness of a hybrid HIIT exercise protocol utilizing whole-body functional-type movements in a circuit fashion. FFIT's total duration of 40 weeks coincided with previous reports suggesting that prolonged exercise interventions induce a far greater reduction in fat mass in obese adults when compared to short-lived protocols (Jensen, 2014; Vanhees et al., 2012). Moreover, our intention was to exceed the period usually needed to observe changes in the anthropometric profile of overweight/obese individuals (i.e. six months) and include a period of potential regain of body mass following the initial loss (Jensen et al., 2014).

Although a higher frequency (5 vs. 3 days/week) has been shown to be more effective in reducing fat mass during a 3-month CET protocol (Ballor, 1990), FFIT and other HIIT protocols seem to produce substantial results with a lower frequency. It is widely accepted that CET protocols of <150 min/week do not elicit changes in body mass of obese adults, protocols of >150 min/week may induce modest body mass and loss (~2–3 kg), protocols of 224-420 min/week could result in even larger reductions (~5–7.5 kg) and protocols of extreme work volumes usually cause even greater weight loss (Slentz et al., 2005; Vanhees et al., 2012). In contrast to these reports that refer to traditional CET, FFIT and other HIIT protocols may elicit similar or even larger weight loss with intense exercise of only ≤100 min/week (Alvarez, 2017; Higgins et al., 2016). This is a crucial element since high weekly volumes of exercise have been associated with greater attrition rates and lower compliance (Wasfy & Baggish, 2016).

FFIT adapted a progressive overload principle maintaining a relatively high intensity (~80%) as evidenced by the gradual rise of mean heart rate (72-87%), blood lactate (8-12 mM), RPE (13-16), METs (5-7) and VO_2 (18-24 mL/kg/min) during the 10-month intervention. These figures corroborate previous findings suggesting that high-intensity circuit training programs combining traditional CET and RE are more effective in eliciting favorable changes in body composition of overweight/obese adults (Paoli, 2010; Skidmore, 2012). In fact, FFIT used a slightly higher mean intensity (83% vs. 79%) than interval running training that resulted in reduced body fat previously (Sijie, Hainai Fengying, &

Jianxiong, 2012). FFIT's total duration of each exercise session was 18-36 min with net exercise time being 6-24 min and work-to-rest ratio ranging from 1:2 to 2:1. HIIT protocols utilizing high-intensity running of short total duration (<28 min) have been found to be more effective in reducing fat mass, BMI and WHR than traditional low-intensity CET in women (Alvarez, 2017; Heydari, Freund, & Boutcher, 2012; Higgins et al., 2017; Paoli et al., 2010; Sijie et al., 2012). These HIIT programs were characterized by similar work-to-rest ratios ranging from 1:1 to 2:1, a relatively higher mean exercise intensity (HIIE vs. FFIT: 88% vs. 83%HR_{max}), and lower RPE (HIIE vs. FFIT: 13.6 vs. 16.0). However, FFIT maintained these overload characteristics for 40 weeks as compared to the shorter interventional period of previous studies (~12-16 weeks).

FFIT utilized a combination of strength- and endurance-type exercises. The resistance-type training protocols usually employed to treat obesity utilize an intensity of 70% 1RM that progresses to 80-90% 1RM, a total volume of 18-to-30 repetitions (broken into 3-6 sets) of traditional RE exercises, and rest intervals of 2-3 min sets, >60 min of total duration per session, 2-4 times/week (Clark & Goon, 2015). FFIT resistance exercises utilized a lower resistance (<50%) performing whole-body functional exercises at 18-30 repetitions/exercise in 2-3 sets (cycles) with a much smaller work-to-rest ratio at less than 30 min/session.

Adherence and compliance

Anti-obesity programs employing lifestyle interventions such as exercise and/or nutrition protocols in adults with increased BMI (>30 kg/m^2) usually exhibit frustrating success rates mainly due to low adherence and attendance (Miller & Brennan, 2015; Burgess et al., 2017). Attrition rates recorded for weight loss approaches employing exercise, nutritional and weight management (e.g. education- or behavior modification-based) may reach 20-60%, 16-40%, and 18-80%, respectively, resulting in poor outcomes (Miller &

Brennan, 2015). It appears that engaging obese adults in lifestyle modifications such as exercise and fulfilling their goals could be a very challenging task (Burgess et al., 2017) especially in women according to previous studies (Greenberg, Stampfer, Schwarzfuchs, & Shai, 2009; Honas, Early, Frederickson, & O'Brien, 2003). The FFIT protocol exhibited a 6% attrition rate, defined according to a recent study (Miller & Brennan, 2015), and 94% attendance rates during a 10-month implementation period. Factors that may result in increased attrition rates include practical/personal (e.g. occupation, family environment, health status, logistics), psychological (e.g. low self-confidence and motivation, not willing to make changes, etc.), and program-specific (e.g. personnel/staff, research environment, failure to lose weight) factors (Miller & Brennan, 2015). An explanation of the exceptionally low attrition rate achieved in this trial cannot be offered now. Future research should examine whether small-group, hybrid-type exercise protocols demonstrate high adherence rates consistently and why.

Conclusions

An injury-free, hybrid, and time-effective exercise training program combining some of the worldwide top future trends in the health and fitness industry (Thompson, 2016) and consisting of endurance exercise and whole-body functional type resistance exercises and of limited total duration organized in a small-group setting induces favorable adaptations in body mass and FM of overweight/obese women. These changes seem to be related to an increase in RMR, FFM and possibly to metabolic adaptations. Body mass and FM regain due to extensive detraining was limited suggesting that this type of exercise training protocol and programming may play a key role for weight maintenance, which is an important element for a long-term weight management and improvements in health and performance of adult population (ACSM, 2014).

Practical applications

Since the prevalence of physical inactivity and obesity are higher than never at global level, exercise professionals may have to provide a circuit-based full body routine that combines HIIT, RE, and FT. Thus, a functional hybrid training workout seems as a time-effective and evidence-based exercise modality that induces significant improvements in physiological and metabolic parameters. More specifically, both a 20-week and a 40-week exercise interventions based on the above training characteristics are sufficient for improvements in body mass, body composition, cardiorespiratory power, and muscle strength in sedentary overweight/obese women. In summary, FFIT workout is an effective time-efficient method of improving health determinants in sedentary overweight/obese women through supervised and hybrid small-group training sessions whereas a 20-week detraining period does not seem competent to alter the adaptations to the baseline levels.

All these facts indicate that this novel exercise training program could become a science-based exercise training methodology that would be able to serve efficiently the most prevailing type of global population. Moreover, a workout that combines the top fitness trends worldwide (Thompson, 2016) with an injury-free and fun exercise programming may be an attractive and evidence-based training solution within the health and fitness industry. An approach of this kind could have a serious impact for encouraging exercise participation and resultant improvements in health, wellness, and performance.

Recommendations for future research

Additional research is required to examine the contributing factors and cellular pathways that facilitate the metabolic adaptations. Further studies may also wish to examine whether this type of exercise can improve markers of health in individuals at risk for developing inactivity-related diseases such as cardiovascular disease, metabolic syndrome, dyslipidemia, and type 2 diabetes. Our results are limited to the sedentary female population, and investigations into the effectiveness of FFIT workout on measures of aerobic capacity and muscular strength are warranted in the male population. Additionally, future studies should examine the FFIT workout in seniors or/and trained subjects in order to investigate the effects of this novel hybrid program in totally different type of people compared to that we used at the present study. Considerations toward further measures relative to functional capacity, balance, coordination, flexibility, muscular endurance, insulin resistance, and blood lipids could be addressed in the future.

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APPENDIX I: Physical Activity Readiness Questionnaire (PAR-Q)

Physical Activity Readiness Questionnaire (PAR-Q) & You

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active. If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor. Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly:

YES	NO	
☐	☐	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2. Do you feel pain in your chest when you do physical activity?
☐	☐	3. In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

If you answered:

YES to one or more questions

Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- Take part in a fitness appraisal – this

Delay becoming much more active:

- If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- If you are or may be pregnant – talk to your doctor

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

Name ________________________________ Signature ______________________________ Date ________________________________

APPENDIX II: Medical history and screening form

MEDICAL HISTORY QUESTIONNAIRE

This is your medical history form, to be completed prior to your first training session. All information will be kept confidential. This information will be used for the evaluation of your health and readiness to begin our exercise program. The form is extensive, but please try to make it as accurate and complete as possible. Please take your time and complete it carefully and thoroughly, and then review it to be certain you have not left anything out. Your answers will help us design a comprehensive program that meets your individual needs.

If you have questions or concerns, we will help you with those after this form is completed. We realize that some parts of the form will be unclear to you. Do your best to complete the form. Your questions will be thoroughly addressed afterwards. It might be helpful for you to keep a written list of questions or concerns as you complete the medical history form.

Name: ____

Date: ____

MEDICAL HISTORY AND SCREENING FORM

General Information

Participant:

Name ____

Address ____

Contact phone numbers ____________________________________

Birth date ____

Family Physician and/or Primary Health Care Provider:

Doctor/Other ____________________ Phone ____________________

Address ____________________ City ____________________

May I send a copy of your consultation to your physician or primary health care provider and consult with them as necessary?

☐ Yes ☐ No

Signature:

Marital Status:

☐ Single ☐ Married ☐ Divorced ☐ Widowed

Sex:

☐ Male ☐ Female

Education:

☐ Grade School ☐ Jr. High School ☐ High School

☐ College (2-4 years) ☐ Graduate School ☐ Degree ________________

Occupation:

Position ____________________ Employer ____________________

Address ____

Phone ____

What is (are) your purpose (s) for participation in this Fitness Program?

- ☐ To determine my current level of physical fitness and to receive recommendations for an exercise program.
- ☐ Other (please explain) ____

____
____
____
____

Present Medical History

Check those questions to which you answer yes (leave the others blank).

- ☐ Has a doctor ever said your blood pressure was too high?
- ☐ Do you ever have pain in your chest or heart?
- ☐ Are you often bothered by a thumping of the heart?
- ☐ Does your heart often race?
- ☐ Do you ever notice extra heartbeats or skipped beats?
- ☐ Are your ankles often badly swollen?
- ☐ Do cold hands or feet trouble you even in hot weather?
- ☐ Has a doctor ever said that you have or have had heart trouble, an abnormal electrocardiogram (ECG or EKG), heart attack or coronary?
- ☐ Do you suffer from frequent cramps in your legs?
- ☐ Do you often have difficulty breathing?
- ☐ Do you get out of breath long before anyone else?
- ☐ Do you sometimes get out of breath when sitting still or sleeping?
- ☐ Has a doctor ever told you your cholesterol level was high?
- ☐ **Has a doctor ever told you that you have an abdominal aortic aneurysm?**
- ☐ **Has a doctor ever told you that you have critical aortic stenosis?**

Comments: ____

____
____
____

Do you now have or have you recently experienced:

- ☐ Chronic, recurrent or morning coughs?
- ☐ Episode of coughing up blood?
- ☐ Increased anxiety or depression?
- ☐ Problems with recurrent fatigue, trouble sleeping or increased irritability?
- ☐ Migraine or recurrent headaches?
- ☐ Swollen or painful knees or ankles?
- ☐ Swollen, stiff or painful joints?
- ☐ Pain in your legs after walking short distances?
- ☐ Foot problems?
- ☐ Back problems?
- ☐ Stomach or intestinal problems, such as recurrent heartburn, ulcers, constipation or diarrhea?
- ☐ Significant vision or hearing problems?

- ☐ Recent change in a wart or a mole?
- ☐ Glaucoma or increased pressure in the eyes?
- ☐ Exposure to loud noises for long periods?
- ☐ An infection such as pneumonia accompanied by a fever?
- ☐ Significant unexplained weight loss?
- ☐ A fever, which can cause dehydration and rapid heart beat?
- ☐ A deep vein thrombosis (blood clot)?
- ☐ A hernia that is causing symptoms?
- ☐ Foot or ankle sores that won't heal?
- ☐ Persistent pain or problems walking after you have fallen?
- ☐ Eye conditions such as bleeding in the retina or detached retina?
- ☐ Cataract or lens transplant?
- ☐ Laser treatment or other eye surgery?

Comments: ____

____

____

____

Women only answer the following. Do you have:

- ☐ Menstrual period problems?
- ☐ Significant childbirth - related problems?
- ☐ Urine loss when you cough, sneeze or laugh?

Date of the last pelvic exam and / or Pap smear ______________________________

Comments: ____

____

____

____

Are you on any type of hormone replacement therapy? ______________________________

Men and women answer the following:

List any prescription medications you are now taking: ______________________________

____

____

List any self-prescribed medications, dietary supplements, or vitamins you are now taking: __________

____

____

Date of last complete physical examination: ______________________________

☐ Normal ☐ Abnormal ☐ Never ☐ Can't remember

Date of last chest X-ray: ______________________________

☐ Normal ☐ Abnormal ☐ Never ☐ Can't remember

Date of last electrocardiogram (EKG or ECG): ____________

☐ Normal ☐ Abnormal ☐ Never ☐ Can't remember

Date of last dental check up: ____________________

☐ Normal ☐ Abnormal ☐ Never ☐ Can't remember

List any other medical or diagnostic test you have had in the past two years: ________________

____

____

List hospitalizations, including dates of and reasons for hospitalization: ____________________

____

____

List any drug allergies: ______________________________

____

____

Past Medical History

Check those questions to which your answer is yes (leave others blank).

- ☐ Heart attack if so, how many years ago? ________
- ☐ Rheumatic Fever
- ☐ Heart murmur
- ☐ Diseases of the arteries
- ☐ Varicose veins
- ☐ Arthritis of legs or arms
- ☐ Diabetes or abnormal blood-sugar tests
- ☐ Phlebitis (inflammation of a vein)
- ☐ Dizziness or fainting spells
- ☐ Epilepsy or seizures
- ☐ Stroke
- ☐ Diphtheria
- ☐ Scarlet Fever
- ☐ Infectious mononucleosis
- ☐ Nervous or emotional problems

- ☐ Anemia
- ☐ Thyroid problems
- ☐ Pneumonia
- ☐ Bronchitis
- ☐ Asthma
- ☐ Abnormal chest X-ray
- ☐ Other lung disease
- ☐ Injuries to back, arms, legs or joint
- ☐ Broken bones
- ☐ Jaundice or gall bladder problems

Comments: ____
____
____
____

Family Medical History

Father:

☐ Alive Current age ____________

My father's general health is:

☐ Excellent ☐ Good ☐ Fair ☐ Poor

Reason for poor health: ____

☐ Deceased ☐ Age at death ________________

Cause of death: ____

Mother:

☐ Alive Current age ____________

My mother's general health is:

☐ Excellent ☐ Good ☐ Fair ☐ Poor

Reason for poor health:____

☐ Deceased ☐ Age at death ________________

Cause of death: ____

Siblings:

Number of brothers _______ Number of sisters _______ Age range _________________________

Health problems ____

Familial Diseases

Have you or your blood relatives had any of the following (include grandparents, aunts and uncles, but exclude cousins, relatives by marriage and half-relatives)?

Check those to which the answer is yes (leave other blank).

- ☐ Heart attacks under age 50
- ☐ Strokes under age 50
- ☐ High blood pressure
- ☐ Elevated cholesterol
- ☐ Diabetes
- ☐ Asthma or hay fever
- ☐ Congenital heart disease (existing at birth but not hereditary)
- ☐ Heart operations
- ☐ Glaucoma
- ☐ Obesity (20 or more pounds overweight)
- ☐ Leukemia or cancer under age 60

Comments: ____

____

____

____

Other Heart Disease Risk Factors

Smoking

Have you ever smoked cigarettes, cigars or a pipe?

☐ Yes ☐ No

(If no, skip to diet section)

If you did or now smoke cigarettes, how many per day? _______________ Age started ___________

If you did or now smoke cigars, how many per day? ___________________ Age started ___________

If you did or now smoke a pipe, how many pipefuls a day? _________________ Age started ___________

If you have stopped smoking, when was it? ____

If you now smoke, how long ago did you start? ____

Diet

What do you consider a good weight for yourself? ____

What is the most you have ever weighed (including when pregnant)? ________________________________

How old were you? _____________________

My current weight is: ____________________

One year ago my weight was: ______________

At age 21 my weight was: _________________

Number of meals you usually eat per day: ____

Number of times per week you usually eat the following:

Beef ________________ Fish _______________ Desserts _______________

Pork ________________ Fowl _______________ Fried Foods ____________

Number of servings (cups, glasses, or containers) per week you usually consume of:

Homogenized (whole) milk ______________ Buttermilk ______________________ Skim (nonfat) milk ___

2% (low-fat) milk ______________________ 1% (low-fat) milk ________________ Coffee ______________

Tea (iced or not) _______________________ Regular or diet sodas ______________ Glasses of water _____

Do you ever drink alcoholic beverages?

☐ Yes ☐ No

If yes, what is your approximate intake of these beverages?

Beer:

☐ None ☐ Occasional ☐ Often If often, _____ per week

Wine:

☐ None ☐ Occasional ☐ Often If often, _____ per week

Hard Liquor:

☐ None ☐ Occasional ☐ Often If often, _____ per week

At any time in the past, were you a heavy drinker (consumption of six ounces of hard liquor per day or more)?

☐ Yes ☐ No

Comments: ____

____

____

____

Do you usually use oil or margarine in place of high cholesterol shortening or butter?

☐ Yes ☐ No

Do you usually abstain from extra sugar usage?

☐ Yes ☐ No

Do you usually add salt at the table?

☐ Yes ☐ No

Do you eat differently on weekends as compared to weekdays?

☐ Yes ☐ No

Comments: ____

____

____

____

APPENDIX III: Informed consent form (in Greek)

ΕΝΤΥΠΟ ΣΥΝΑΙΝΕΣΗΣ ΔΟΚΙΜΑΖΟΜΕΝΟΥ ΣΕ ΕΡΕΥΝΗΤΙΚΗ ΕΡΓΑΣΙΑ

Τίτλος Ερευνητικής Εργασίας: Η επίδραση της διαλειμματικής κυκλικής προπόνησης με λειτουργικές ασκήσεις στη φυσική απόδοση, ευεξία και υγεία υπέρβαρων γυναικών.

Επιστημονικός Υπεύθυνος-η: Αθανάσιος Τζιαμούρτας, Αναπληρωτής Καθηγητής, ΤΕΦΑΑ, ΠΘ,
email: ajamurt@pe.uth.gr, τηλ.: 2431047054.

Ερευνητές: Αλέξιος Μπατρακούλης (email: alexis_batrakoulis_75@hotmail.com, τηλ.: 6932547539)

1. Σκοπός της ερευνητικής εργασίας

Σκοπός της μελέτης είναι να αξιολογήσει τις επιδράσεις μιας συστηματικής εφαρμογής ενός προγράμματος διαλειμματικής κυκλικής προπόνησης με λειτουργικές ασκήσεις στη φυσική απόδοση, ευεξία και υγεία υπέρβαρων προεμμηνοπαυσιακών και αγύμναστων γυναικών ηλικίας 30-45 ετών.

2. Διαδικασία

- Η μελέτη έχει τρείς φάσεις. Πρώτη φάση είναι η περίοδος πριν την έναρξη εφαρμογής ενός προπονητικού προγράμματος, δεύτερη φάση είναι η περίοδος εφαρμογής ενός προπονητικού προγράμματος διάρκειας 12 εβδομάδων και τρίτη φάση είναι η περίοδος μετά την εφαρμογή του προπονητικού προγράμματος.
- Σε όλη τη διάρκεια της μελέτη δεν πρέπει να πάρετε παυσίπονο ή αντιφλεγμονώδες και ας νιώσετε «πιάσιμο» μετά την άσκηση.

<u>Αρχική αξιολόγηση:</u>

- Θα απαντήσεις σε ένα ερωτηματολόγιο υγείας, ευεξίας, επιπέδων σωματικής δραστηριότητας και ποιότητα ζωής.
- Θα σου δοθεί συσκευή με την οποία θα καταγράφονται τα επίπεδα σωματικής δραστηριότητας σου για μία εβδομάδα – αυτές οι πληροφορίες θα σε βοηθήσουν να κατανοήσεις καλύτερα το προπονητικό σου επίπεδο.
- Θα συμμετάσχεις στη διαδικασία μέτρησης ανθρωπομετρικών χαρακτηριστικών όπως σωματικό βάρος, ύψος, περιφέρεια κοιλιάς, μέσης και ισχίων. Επίσης θα μετρηθεί το ποσοστό σωματικού λίπους με δερματοπτυχομέτρηση εφτά σημείων (στήθους, υποπλάτιου, τρικεφάλου, δικεφάλου, λαγόνιου, κοιλιακού, μηριαίου) και με απορροφησιομετρία ακτίνων Χ διπλής ενέργειας με συσκευή DXA σε εργαστήριο.
- Θα συμμετάσχεις στη μέτρηση του βασικού μεταβολισμού ηρεμίας κατόπιν 12ωρης νηστείας φορώντας μια ειδική μάσκα προσώπου συνδεδεμένη με ηλεκτρονικό υπολογιστή και ειδικό λογισμικό καταγραφής των αερίων (οξυγόνο, διοξείδιο του άνθρακα), ενώ θα βρίσκεσαι ξαπλωμένη σε έναν απομονωμένο χώρο του εργαστηρίου για περίπου 45 λεπτά.
- Θα εκτελέσεις μια δοκιμασία περπατήματος ή τρεξίματος στο δαπεδοεργόμετρο για την μέτρηση της μέγιστης πρόσληψης οξυγόνου, ώστε να υπολογιστεί το ατομικό αναερόβιο

κατώφλι. Η δοκιμασία θα πραγματοποιηθεί μία φορά κατά την έναρξη της μελέτης και θα διαρκέσει περίπου 30 λεπτά και θα επαναληφθεί για μία ακόμα φορά στην τελική φάση της μελέτης.

- Θα σου ζητηθεί μία εβδομάδα πριν την έναρξη του προγράμματος να συμμετάσχεις στη φάση εξοικείωσης (τρεις προπαρασκευαστικές συνεδρίες), ώστε να εξοικειωθείς με την τεχνική εκτέλεση των επιλεγμένων ασκήσεων και την ευχέρεια διαχείρισης του απαιτούμενου εξοπλισμού, που αφορούν τόσο στην αξιολόγηση της μυϊκής δύναμης και μυϊκής αντοχής όσο και στο κύριο μέρος του προγράμματος των 12 εβδομάδων.

<u>Προπονητική παρέμβαση και συλλογή δεδομένων:</u>

- Θα ενταχθείς σε μια πειραματική ομάδα προπόνησης. Οι εθελοντές τοποθετούνται στις ομάδες με τυχαίο τρόπο. Οι ομάδες θα εκτελούν για 12 εβδομάδες το παρακάτω πρωτόκολλο. Διαλειμματική κυκλική προπόνηση με λειτουργικές ασκήσεις υπομέγιστης έντασης. Η συνολική διάρκεια της συνεδρίας θα είναι 45-60 λεπτά, η συχνότητα τρεις φορές την εβδομάδα και το ασκησιολόγιο θα περιλαμβάνει τη χρήση του σωματικού βάρους και οκτώ διαφορετικών φορητών εξαρτημάτων λειτουργικής προπόνησης.

<u>Θα γίνουν:</u>

- Στην διάρκεια της αρχικής αξιολόγησης (πρώτη φάση) θα πραγματοποιηθεί αιμοληψία για να αξιολογηθούν δείκτες υγείας όπως το σάκχαρο και τα λιπίδια (ολική χοληστερόλη, HDL, LDL, τριγλυκερίδια). Συνολικά θα απαιτηθούν δύο δείγματα τριχοειδικού αίματος (πριν και μετά). Επίσης, θα αξιολογηθεί η αρτηριακή πίεση ηρεμίας και όλες οι παράμετροι φυσικής κατάστασης (καρδιοαναπνευστική αντοχή, μυϊκή δύναμη, μυϊκή αντοχή, ευλυγισία, ισορροπία, συντονισμός). Οι μετρήσεις αυτές θα επαναληφθούν στη διάρκεια της τελικής αξιολόγησης και 96 ώρες μετά την ολοκλήρωση της τελευταίας συνεδρίας (τρίτη φάση).
- Πριν και μετά τη συμμετοχή σου στο πρόγραμμα άσκησης θα γίνει αξιολόγηση της σωματικής σύστασης με απορροφησιομετρία διπλής δέσμης ακτίνων X μέσω ειδικής συσκευής (DXA) και δερματοπτυχομέτρηση σε επτά σημεία. Επίσης, μέτρηση του βασικού μεταβολικού ρυθμού ηρεμίας κατόπιν 12ώρης νηστείας και αξιολόγηση της καρδιοαναπνευστικής αντοχής (αερόβιας ικανότητας) μέσω υπομέγιστης εργοδοκιμασίας σε δαπεδοεργόμετρο.

3. Κίνδυνοι και ενοχλήσεις

<u>Προπόνηση:</u>
Η προπόνηση είναι μία αβλαβής διαδικασία η οποία όμως θα σου προκαλέσει μία ολιγόλεπτη κόπωση. Θα παρακολουθείται συνεχώς η καρδιακή σας συχνότητα και αν νοιώσεις εξάντληση ή αδιαθεσία θα σταματήσεις αμέσως. Επίσης, θα υπάρχει πρόβλεψη πρώτων βοηθειών και εκπαιδευμένο προσωπικό για κάθε ενδεχόμενο.

<u>Αιμοληψία:</u>
Θα χρησιμοποιηθεί μία μικρή βελόνα σύριγγας για τη λήψη φλεβικού αίματος από τη μεσοβασιλική φλέβα. Υπάρχει πιθανότητα μικρού μώλωπα στο σημείο της αιμοληψίας ενώ μπορεί να αισθανθείς πόνο κατά τη διάρκεια της αιμοληψίας και ζαλάδα ή τάσεις λιποθυμίας τόσο κατά τη διάρκεια όσο και μετά από την αιμοληψία. Η συνολική ποσότητα αίματος που θα ληφθεί από έμπειρο ιατρό θα είναι 10 ml (ανά αιμοληψία) η οποία δεν θα έχει απολύτως καμία αρνητική συνέπεια.

Δοκιμασίες άσκησης:
Δεν θα επιτραπεί σε άτομα με μη φυσιολογικό ηλεκτροκαρδιογράφημα (ΗΚΓ) ηρεμίας ή με συστολική πίεση ηρεμίας >160 mmHg και/ή διαστολική πίεση ηρεμίας >95 mm Hg να συμμετάσχουν στις δοκιμασίες άσκησης της μελέτης. Κατά τη διάρκεια των μετρήσεων της αερόβιας ικανότητας θα ακολουθηθούν αυστηρές προδιαγραφές ασφάλειας, παρουσία ιατρικού προσωπικού. Σε περίπτωση ανεπιθύμητων ενδείξεων η συμπτωμάτων (π.χ. στηθάγχη, δύσπνοια, ισχαιμία κ.λπ.), η δοκιμασία άσκησης θα τερματίζεται άμεσα. Οι μετρήσεις δύναμης θα γίνουν σε μηχανήματα μυϊκής ενδυνάμωσης με υποστήριξη του σωματικού βάρους, παρουσία βοηθών και καρδιολόγου. Θα προκληθεί μόνο στιγμιαία κόπωση και σε καμία περίπτωση εξάντληση.

Μέτρηση οστικής πυκνότητας:
Κατά τη διάρκεια της εξέτασης θα δεχτείς πολύ μικρή δόση ακτινοβολίας X η οποία αντιστοιχεί σε περίπου 15 μGy (μικρότερη από το 1/10 της δόσης που λαμβάνει κανείς από μία ακτινογραφία θώρακος, ενώ είναι μικρότερη ακόμη και από την καθημερινή δόση ακτινοβολίας που λαμβάνει κάθε άτομο ακούσια από το περιβάλλον ή από μία αεροπορική πτήση διάρκειας περίπου 10 ωρών). Η εξέταση θα διαρκέσει συνολικά λιγότερο από 30 λεπτά και δεν θα υπάρξει κάποια αρνητική επίδραση στην υγεία σου.

Υπόλοιπες μετρήσεις:
Η αξιολόγηση του βασικού μεταβολισμού, μέτρησης του σωματικού σας βάρους, ύψους, λίπους καθώς και της ευλυγισίας και της λειτουργικής σας απόδοσης, είναι εντελώς αβλαβείς και χωρίς κανέναν κίνδυνο για την υγεία σας.

4. Προσδοκώμενες ωφέλειες

Με την συμμετοχή σου θα λάβεις πολλές πληροφορίες για το λειτουργικό σου προφίλ, τη σωματική σου ικανότητα και δείκτες της υγείας και ευεξίας σου. Θα ασκηθείς συστηματικά για όλες τις εβδομάδες που προβλέπει το ερευνητικό πρόγραμμα με στενή παρακολούθηση και επίβλεψη από εξειδικευμένο προσωπικό γυμναστή σε ατομικές ή και ομαδικές συνεδρίες λίγων ατόμων και θα σου δοθεί εξατομικευμένο εβδομαδιαίο πρόγραμμα διατροφής από διαιτολόγο-διατροφολόγο, που στην αγορά των γυμναστηρίων κοστίζουν > 750 ευρώ. Παράλληλα, θα σου δοθεί εξατομικευμένο εβδομαδιαίο πρόγραμμα διατροφής από διαιτολόγο-διατροφολόγο. Επίσης θα λάβεις δωρεάν αποτελέσματα από αξιολογήσεις που στο εμπόριο κοστίζουν > 750 ευρώ. Η διερεύνηση των βιοχημικών και φυσιολογικών επιδράσεων της άσκησης θα αποτελέσει τη βάση για την χρήση της άσκησης ως αποτελεσματικό τρόπο προπόνησης ασκούμενων, υγιών ή και ασθενών, προς ωφέλεια του κοινωνικού συνόλου.

5. Δημοσίευση δεδομένων – αποτελεσμάτων

Η συμμετοχή σου στην έρευνα συνεπάγεται ότι συμφωνείς με τη δημοσίευση των δεδομένων και των αποτελεσμάτων της, με την προϋπόθεση ότι οι πληροφορίες θα είναι ανώνυμες και δε θα αποκαλυφθούν τα ονόματα των συμμετεχόντων. Τα δεδομένα που θα συγκεντρωθούν θα κωδικοποιηθούν με αριθμό, ώστε το όνομα σου δε θα φαίνεται πουθενά.

6. Πληροφορίες

Μη διστάσεις να κάνεις ερωτήσεις γύρω από το σκοπό, τον τρόπο πραγματοποίησης της εργασίας ή τον υπολογισμό της λειτουργικής σου ικανότητας. Αν έχεις κάποιες αμφιβολίες ή ερωτήσεις, ζήτησέ μας να σου δώσουμε πρόσθετες εξηγήσεις.

7. **Ελευθερία συναίνεσης**

Η συμμετοχή σου στην εργασία είναι εθελοντική. Είσαι ελεύθερη να μην συναινέσεις ή να διακόψεις τη συμμετοχή σου όποτε το επιθυμείς.

8. **Δήλωση συναίνεσης**

Η άδειά σου να συμμετάσχεις στην εργασία είναι εθελοντική. Είσαι ελεύθερη να μην συναινέσεις ή να διακόψεις τη συμμετοχή σου όποτε επιθυμείς.

Ημερομηνία: 25/5/2015

Ονοματεπώνυμο και υπογραφή συμμετέχοντος	Υπογραφή ερευνητή

APPENDIX IV: 3-day Diet Analysis Intake Form

DIETARY ASSESSMENT - ESTIMATED FOOD DIARY

Fill out the following information as accurately as possible. Include one weekend day and 2 other days to provide a record that reflects day-to-day variability in your food consumption. Our analysis will average these 3 days. Incomplete forms **cannot** be analyzed. Use the example given as a guide to develop your detailed food intake record. Use additional pages as necessary.

Day of week and meal eaten	**Food or Beverage** Give a detailed description including type of food, brand name, or restaurant	**Amount Eaten** Give as tsp, tbsp, cups, oz, weight or portion	**How Prepared?** Provide description, product label or recipe if available.	**Where eaten?**	**Added fat, salt or sugar?**
Example: Mon 1/9 breakfast	*Scrambled eggs*	*1 whole large egg*	*Scrambled in 1tsp butter with 1 tbsp 1% milk added*	*In front of TV*	*Dash of salt & pepper*
Mon 1/9 breakfast	*Bread with margarine and jelly*	*1 slice 1tsp of each*	*Toasted*	*Same as above*	*1 tsp marg (butter or marg) + 1 tsp jelly (regular or lite)*
Mon 1/9 breakfast	Orange Juice	16 oz	Jewel-Osco brand	Same as above	100% juice; not sweetened
Day of week and meal eaten	**Food or Beverage** Give a detailed description including type of food, brand	**Amount Eaten** Give as tsp, tbsp, cups, oz,	**How Prepared?** Provide description, product label or recipe if available.	**Where eaten?**	**Added fat, salt or sugar?**

Day of week and meal eaten	**Food or Beverage** Give a detailed description including type of food, brand name, or restaurant	**Amount Eaten** Give as tsp, tbsp, cups, oz, weight or portion	**How Prepared?** Provide description, product label or recipe if available.	**Where eaten?**	**Added fat, salt or sugar?**

Name_________________________ **Date**________________________

Height_________________________ **Weight**______________________