UNIVERSITI PUTRA MALAYSIA

EFFECTS OF GAMMA ORYZANOL SUPPLEMENTATION ON LIPID PROFILE, ANABOLIC/CATABOLIC HORMONES, CIRCULATING BINDING PROTEINS AND ANTHROPOMETRIC CHANGES IN YOUNG MALES DURING RESISTANCE TRAINING

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By

SAGHAR ESLAMI

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Thesis Submitted to School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of Degree of Doctor of Philosophy

July 2012

DEDICATION

This thesis is dedicated to my parents who have supported me all the way since the beginning of my studies.

Also, this thesis is dedicated to my fiancé who has been a great source of motivation and inspiration.

Finally, this thesis is dedicated to all those who believe in the richness of learning.

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for degree of Doctor of Philosophy

EFFECT OF GAMMA ORYZANOL SUPPLEMENTATION ON LIPID PROFILE, ANABOLIC/CATABOLIC HORMONES, CIRCULATING BINDING PROTEINS AND ANTHROPOMETRIC CHANGES IN YOUNG MALES DURING RESISTANCE TRAINING

By

SAGHAR ESLAMI

July 2012

Chair: **Associate Professor Norhaizan Mohd. Esa, PhD**

Faculty: **Medicine & Health Sciences**

Resistance training is an element of conditioning and training for almost any sports. Speeded muscle strength increments are seen whenever resistance exercise is joined by the consumption of nutritional supplements. Although, there are very limited researches about the efficacy of gamma oryzanol supplementation with resistance exercise in humans, the usage of gamma oryzanol in strength athletes is prevalent. The aim of this single blind, placebo-controlled, randomized intervention trial is to determine the effects of dietary 600 mg/day gamma oryzanol supplementation during a 9-week resistance training program on altering lipid profile, anabolic/catabolic hormones, circulating binding proteins and anthropometric measures of young males during resistance training.

Thirty two eligible males with no continuous resistance training experience during six months before the study participation, with age 18-24 years were selected for the study. They were randomized into two groups (either 600 mg of gamma oryzanol or lactose in the form of capsules). Prior to the study commencement, subjects' one-

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Repetition Maximum (1-RM) was determined by means of 1-RM strength tests on the regular leg curl and bench press machine, which was repeated on the last day of study. On the commencement day and the last day of the study, they were examined for anthropometric and body measurements. Supervised resistance training was performed four times a week, performing three sets (consisting of 6–12 repetitions) per exercise with three minutes rest, for a period of 9 weeks for each participant, accompanied with the consumption of supplement. At the study commencement in two times, before and after the acute resistance exercise, and at the end of the 9-week and 24 hours after the last resistance exercise performance, blood sampling were taken following 10-12 hour fast. Independent sample t-test and general linear model were applied to compare within and between group differences in mean scores. In terms of analyzing hormonal changes and blood protein levels over 4 time points of sampling, data were analyzed with 2×4 (Group × Time points) repeated measures analysis of variance. Bonferroni corrected post hoc test was used for analyzing difference of changes between time points. All testing of hypotheses were two-tailed, with significant judgment by 95% confidence interval and $p<0.05$.

There was no significant difference between the baseline characteristics and the target variables at baseline. In terms of anthropometric changes, there was no significant change between the supplement and placebo groups after the 9-week intervention. On the other hand, 1-RM of bench press ($p<0.001$) and leg curl ($p=0.005$), which are markers of muscle strength increased after gamma oryzanol supplementation in the supplement group compared with placebo group.

Among markers of blood lipid profile, very low-density lipoprotein (VLDL-C) ($p=0.034$) and triglyceride (TG) ($p=0.027$) levels declined in the supplement group

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greater than the placebo group after the 9-week supplementation which shows the effect of gamma oryzanol supplementation on decreasing these markers, but no difference has been shown for high-density lipoprotein (HDL-C), low-density lipoprotein (LDL-C) and total cholesterol (TC) ($p>0.05$). In terms of serum mineral concentration, there was only significant difference between the supplement and placebo groups for zinc concentration after the 9-week intervention.

During the study, it has been observed that gamma oryzanol affected on total testosterone ($p=0.041$), cortisol ($p=0.010$) and growth hormone (GH) ($p=0.047$) levels, unlike free testosterone, triiodothyronine (T3), thyroxine (T4), thyroid-stimulating hormone (TSH), insulin-like growth factor-I (IGF-I), estradiol, dehydroepiandrosterone sulfate (DHEAS), sex hormone-binding globulin (SHBG), epinephrine, norepinephrine and insulin-like growth factor-binding protein 3 (IGFBP3) ($p>0.05$). Moreover, testosterone to cortisol ratio significantly changed ($p<0.001$) in the supplement group compared with the placebo group; however, no significant change was shown for total testosterone to SHBG ratio ($p>0.05$) between the supplement and placebo groups.

In conclusion, the current study demonstrated that gamma oryzanol supplementation may benefit resistance athletes to improve anabolic markers as well as increasing muscle strength. However, this supplement could not improve all markers of interest and more researches need to be carried out for understanding the mechanism of effects and substitute this supplement with harmful hormonal drugs and supplements.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN SUPLEMEN GAMMA ORIZANOL KE ATAS PROFIL LIPID, HORMON ANABOLIK / KATABOLIK, 'CIRCULATING BINDING PROTEIN' DAN PERUBAHAN ANTROPOMETRI DI KALANGAN LELAKI MUDA SEMASA LATIHAN RINTANGAN

Oleh

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Julai 2012

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Fakulti: Perubatan & Sains Kesihatan

Latihan rintangan adalah satu elemen 'conditioning' dan latihan untuk hampir semua jenis sukan. Peningkatan kekuatan otot dilihat apabila senaman rintangan disertai oleh pengambilan makanan tambahan. Walaupun kajian terhadap keberkesanan suplemen gamma orizanol dengan senaman rintangan pada manusia adalah amat terhad, tetapi penggunaan gamma orizanol dalam atlet begitu berleluasa. Matlamat ujikaji 'single-blind', dikawal oleh placebo dan intervensi percubaan campur tangan rawak ini adalah untuk menentukan kesan pengambilan supplemen gamma orizanol 600mg/hari dalam diet selama 9 minggu dalam program latihan rintangan akan mengubah dengan signifikan profil lipid, hormon anabolik/katabolik, 'circulating binding protein' dan ukuran antropometri di kalangan lelaki muda semasa latihan rintangan.

Tiga puluh dua orang lelaki yang layak tanpa pengalaman menyertai latihan rintangan yang berterusan lebih daripada enam bulan sebelum menyertaan kajian ini, dengan umur 18-24 tahun telah dipilih untuk kajian. Mereka dibahagikan secara rawak kepada dua kumpulan (sama ada 600mg gamma orizanol atau laktosa dalam

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bentuk kapsul). Sebelum kajian dimulakan, ulangan maksimum (1-RM) subjek ditentukan melalui ujian kekuatan 1-RM manggunakan mesin 'leg curl', dan 'bench press machine', yang mana ianya akan diulang lagi pada hari terakhir kajian. Pada awal dan akhir kajian, ukuran antropometeri dan badan responden diambil. Latihan jenis rintangan yang diselia dilakukan sebanyak empat kali seminggu, 3 set (terdiri daripada 6-12 ulangan) setiap senaman dengan 3 minit rehat, untuk tempoh 9 minggu bagi setiap peserta bersama dengan pengambilan makanan tambahan. Pada permulaan dua kajian ini iaitu sebelum dan selepas rintangan akut dijalankan, dan pada akhir minggu ke 9 dan 24 jam selepas senaman rintangan yang terakhir, pengukuran serta pensampelan darah dilakukan selepas 10-12 jam berpuasa, di tempat yang sama di mana responden menjalani latihan. Sampel Bebas Ujian-t dan model linear umum telah digunakan untuk membandingkan perbezaan di dalam dan di antara kumpulan dalam skor min. Dari segi analisis perubahan hormon dan paras 'protein' dalam darah untuk empat waktu persampelan, data telah dianalisis dengan 2 × 4 (Kumpulan × waktu pensampelan) analisis variasi berulang. Ujian 'Post hoc corrected bonferroni' telah digunakan untuk menganalisis perbezaan perubahan antara masa. Semua ujian hipotesis adalah 'two-tailed' dan signifikan sekiranya selang keyakinan adalah 95% dan $p < 0.05$.

Tiada perbezaan yang signifikan di antara ciri-ciri awal dengan pembolehubah sasaran di peringkat awal. Dari segi perubahan antropometri, tidak terdapat perbezaan yang signifikan di antara kumpulan yang mengambil gamma orizanol dan plasebo selepas 9 minggu intervensi. Sebaliknya, '1-RM bench press' ($p<0.001$) dan 'leg curl' ($p = 0.005$), iaitu penanda kekuatan otot telah meningkat pada responden yang menerima suplemen gamma orizanol berbanding kumpulan plasebo.

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I certify that a Thesis Examination Committee has met on 24th July 2012 to conduct the final examination of Saghar Eslami on her thesis entitled "Effect of Gamma Oryzanol Supplementation on Lipid Profile, Anabolic/Catabolic Hormones, Circulating Binding Proteins and Anthropometric Changes in Young Resistance Athletes" in accordance with the Universities and University Colleges Act 1971 and the constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.
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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

_____

SAGHAR ESLAMI

Date: 24 July 2012

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LIST OF ABRREVIATIONS

1-RM	One-Repetition Maximum
AAS	Anabolic/Androgenic Steroids
ACTH	Adrenocorticotropic Hormone
AHRE	Acute Heavy Resistance Protocol
ASMI	American Sports Medicine Institute
BMI	Body Mass Index
BUN	Blood Urea Nitrogen
COMT	Catechol-O-methyltransferase
DHEAS	Dehydroepiandrosterone Sulfate
DHT	Dihydrotestosterone
DSHEA	Dietary Supplement Health and Education Act
FBS	Fasting Blood Sugar
FSH	Follicle-Stimulating Hormone
GH	Growth Hormone
GHRH	Growth Hormone Releasing Hormone
GI	Gastrointestinal

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HDL-C	High Density Lipoprotein-Cholesterol
IGFBP3	Insulin Like Growth Factor Binding Protein 3
IGF-I	Insulin Like Growth Factor-I
IOC	International Olympic Committee
LBM	Lean Body Mass
LDL-C	Low Density Lipoprotein-Cholesterol
LH	Luteinizing Hormone
MCR	Metabolic Clearance Rate
NHANES	National Health and Nutrition Examination Survey
OGTT	Oral Glucose Tolerance Test
SF	Skin Fold
SGOT	Serum Glutamic Oxaloacetic Transaminase
SGPT	Serum Glutamic Pyruvic Transaminase
SHBG	Sex Hormone Binding Globulin
SOD	Superoxide Dismutase
RBO	Rice Bran Oil
T3	Triiodothyronine

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T4	Thyroxin
TC	Total Cholesterol
TG	Triglycerides
TSH	Thyroid Stimulating Hormone
VLDL-C	Very Low Density Lipoprotein-Cholesterol

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Multiple factors affect maximum strength capacity of skeletal muscles, many of them engage in a synergistic manner. The most powerful factor is resistance training, which impressively rises maximal isometric and dynamic muscle contraction strength (Aagaard, 2004). Resistance training is an element of conditioning and training for almost any sport. It is necessary for athletes, particularly who require enlarged lean body mass (LBM). The greater the mass, the greater the potential for increasing strength and power. Enlarged lean body mass is critical for increasing strength and power exhibition, improving stability, and elevating aesthetic appearance through muscle hypertrophy (Tausha, 2000). Resistance training might advance various advantages to body composition, health, and quality of life (Stone, 1991). Resistance training (also named weight or strength training) is identified by the performance of exercises in which muscles from a particular body part are condensed against a power that opposes the movement (Cardoso et al., 2010).

In the last few decades, advances in human metabolism and exercise physiology has clarified that appropriate nutrient intake positively influences sport performance (Molinero & Marquez, 2009). Products which claim to extend endurance, increase recovery, decrease body fat, increase muscle mass, reduce the risk of illness, or improve sports performance, fill the sports world. Several surveys show that athletes are the main consumers of supplements and prominent target groups for the multi-billion dollar supplement industry (Burke et al., 2000). It is easy to know why promises of enhanced performance are appealing to athletes and coaches in elite

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competition, where very petty differences detached the victors from the rest of the field (Hopkins et al., 1999). However, the fame and fortune of Olympic gold medals and world records give only a part of reason for consumption of various sports supplements, since even non-elite and recreational athletes are avid consumers of sports foods and supplements (Burke et al., 2000). As a consequence, many competitive and recreational athletes tend to consume dietary supplements in order to intensify strength training and performance.

Athletes must cautiously evaluate the adequacy of their diets before starting a regimen of expensive and unproven supplements that are proposed to magnify muscular development, muscular strength, or both. Universal supplement consumption in athletes is estimated to range from 40% to 88% (Silver, 2001; Williams, 2005); more than thirty thousand supplements are being commercially available in the USA (Tekin & Kravitz, 2004). Over three million people in the USA alone consume, or have consumed ergogenic supplements (Palmer et al., 2003), and supplement use is similarly common among athletes at high school and collegiate levels. More than 50% of the subjects expended $25 to $100 monthly on supplements, whereas 4.9% reported paying over $150 per month. Supplement usage could be pricey for athletes (Tausha, 2000). Athletes are provided with recommendations or gossip about the advantages that are referred to supplements and sport foods and even in the lack of strong evidence to prove a product, they may be constrained to use it to keep 'level playing field' (Lippi et al., 2008).

Substances such as human growth hormone (hGH) and anabolic / androgenic steroids were consumed in the past and continuing to the present, in the hope of overcoming genetic limitations in hormonal status and in the ability to increase muscle (Houlihan,

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2002). These substances have been related with several health risks and are forbidden by most athletes governing agencies (Houlihan, 2002). Therefore, sports science is enthusiastic in supplements and sports foods as a part of its investigation for new planning to improve training, recovery and competition performance. The applied sport nutrition research, which has helped developing new products, is undertaken by many scientists. In addition, they explore particular methods in which supplements can be used to improve efficiency of performance (Burke et al., 2000). Unfortunately, the numerous challenges to undertake unknowing of such research denote that it is impossible to keep pace with the number of newborn products that rise on the sports market. In fact, the greater part of products are either untried or have gone wrong in the initial studies that have been conducted. Scientists believe that well-controlled research must corroborate the advancement of any sports nutrition practice and they know that manufacturers of supplements regularly make effective claims about their products without sufficient or, in some situations, any evidence. Nevertheless, in most countries, laws regarding supplements or sports foods are either minimal or ineffective, permitting unconfirmed claims and products to be produced with poor concurrence to labeling and composition standards. Athletes are typically unconscious of these failures (Burke et al., 2000).

Plants bring us most nutrients fundamental for life. More than fundamental nutrients, plant foods contain naturally occurring matters, referred to respectively as phytochemicals. Herbals, which are obtained from berries, roots, leaves, gums, stems, flowers or seeds of plants, contain numerous phytochemicals supposed to have nutritive or medicinal advantages. In history, and have been used as medicine (Williams, 2006). Herbals are modulated in various countries as medicine, such as

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Germany, but as dietary supplements in others. At this time, most herbals are regulated in the United States by the Dietary Supplement Health and Education Act (DSHEA), more like food components than drugs. Nonetheless, assuming the pharmacological influence of different herbals, some health specialists are accentuating the necessity for standardizing herbal therapy (Sengupta et al., 2004; Williams, 2006). In the latest National Health and Nutrition Examination Survey (NHANES) report, closely 7% of the US people comprising athletes obtain herbal or botanical dietary supplements (Ervin et al., 2004). In Europe, herbal supplements represent 5 billion USD commerce, but France and Germany alone account for 60% of the market, proposing that utilization varies by country (De Smet, 2005). Estimations of herbal supplement usage by the population of the United Kingdom differ from 10 to 25% (and are increasing), and herbal supplements presently create a £3.8 million commerce per annum (Harrison et al., 2004; Ritchie, 2007). Likewise, consumption rates of herbal supplements in the US have ascended sharply since the 1990s, from about 3% to about 25% of the citizens by one study or a 380% extension by another (Bent, 2008; Bent & Ko, 2004; Senchina et al., 2009), giving rise to a 4.4 billion USD industry (Blumenthal et al., 2006).

Herbal dietary supplements are traded to physically active subjects for numerous reasons, involving augmenting energy, bringing about weight loss, promoting muscle enlargement, or inducing other physiological or metabolic responses that lead to improved exercise performance (Williams, 2006). Use of herbal supplements in athletes is more common than that of the general community, ranging from 17% to 61% (Froiland et al., 2004; Ziegler et al., 2003). One study found that athletes are more enthusiastic to use herbal supplements than nonathletic subjects (Senchina et

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al., 2009), perhaps because many herbal supplements merchandising campaigns aim at athletes with pledges of increasing performance or lessening side effects of training (Winterstein & Storrs, 2001).

Gamma oryzanol is a ferulic acid ester of sterols extracted from rice bran oil (Berger et al., 2005). Japanese people have approved this substance for several health conditions, including menopausal symptoms, stomach disorder, moderate anxiety, and high blood cholesterol. It is popularly marketed as a sports supplement in the US, as well as for lowering blood cholesterol (Hoogeven & Zonderland, 1996), but there is no official report about the prevalence of using this supplement among athletes or general population in different countries. The profits of gamma oryzanol are provided by increasing levels of GH, testosterone, and other anabolic or muscle building hormones. Even so, there is very limited scientific proof to back up gamma oryzanol effects. Gamma oryzanol has been exhibited to have antioxidant properties. Consequently, it might enhance endurance and muscle building capacity by hindering the production of free radicals in muscle tissue, which theoretically could lessen muscle exhausting and fatigue in reaction to anaerobic exercise (Potricia & Rita, 2004). The profits of gamma oryzanol are provided by increasing levels of GH, testosterone, and other anabolic or muscle building hormones. Even so, there is very limited scientific proof to back up gamma oryzanol effects.

1.2 Problem Statement

Alterations in both neural system and muscular structure and function, as firmly shown in young and elderly subjects, bring about training- induced rise in maximal contractile muscle power. The effect of resistance training on muscle hypertrophy is

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well known. For a long time, resistance athletes have been attracted in knowing which types of nutritional supplementation will give the greatest help in an attempt to maximize the training adaptations in response to resistance training. Speeded muscle strength increments are seen whenever resistance exercise is joined by the consumption of nutritional or ergogenic supplements. Moreover, diverse banned substances and drugs may boost the build-up of muscle mass, leading to amplified gains in maximal muscle strength with training. However, some severe adverse effects arising from the banned supplements consumption are irreversible. Furthermore, the International Olympic Committee (IOC) prohibits anabolic steroids and also they are banned in several countries by virtue of criminal laws (Aagaard, 2004).

Utilization of performance-enhancing supplements takes place at all levels of sports, from trained athletes to junior high school students. In spite of the fact that some supplements improve athletic performance, lots of them have no verified profits and make serious adverse effects in consumers (Maravelias et al., 2005). Resistance athletes vastly use anabolic steroids and ephedrine, which have life-threatening adverse effects, with hope of growing muscle mass and increasing performance. The IOC and the National Collegiate Athletic Association have banned them for the consumption in contests. As a result, an attempt is made to substitute these banned drugs and supplements with effective and safe nutritional ones. In recent years, there has been increasing interest in modeling new natural supplements without adverse side effects to avoid sever irreversible problems in athletes.

Athletes consume gamma oryzanol based on the preliminary studies that proposed gamma oryzanol increases muscle growth and sports performance (Fry & Kraemer,

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1997), by the way of rising levels of testosterone, GH, and other anabolic (muscle-building) hormones. Changes in the endocrine system, including hormonal variations, change in lipid profile explain the suggested performance elevating properties of gamma-oryzanol (Berger, 2005). The antioxidant properties of gamma oryzanol and its derivative, ferulic acid, are promising in some areas (Potricia & Rita, 2004). In athletes, macro elements, like magnesium and calcium, in the ionized form contribute to heart and muscle contractions, oxidative phosphorylation and the synthesis and activation of enzymatic systems. Hence, equilibrating of their concentration is important for athletes. Although, there are very limited studies with regards to the efficacy of gamma oryzanol supplementation with resistance exercise in humans, the usage of this supplement as a nutritional supplement for strength athletes is prevalent (Bruni 1988).

The research to date has tended to focus on gamma oryzanol effects in patients, especially hyperlipidemic patients, rather than on resistance athletes. Just one research has been conducted by Fry and co-workers (1997) for studying effects of gamma oryzanol supplementation on resistance exercise in which their subjects have been chosen from both sexes and adult with age ≥40. Also, the number of subjects for their study was limited which could explain the non-efficiency of supplementation. However, gamma oryzanol has been proposed to have particular properties for improving strength and efficiency of resistance training. Therefore, the aim of the current study is to determine if dietary gamma oryzanol supplementation during a 9-week resistance training program will significantly alter muscular strength, lipid profile, anabolic/catabolic hormones, and anthropometric measures of young males. In doing so, important research questions include;

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1. Does 600mg/day gamma oryzanol supplementation affect anthropometric changes during the 9-week resistance training?

2. Does 600mg/day gamma oryzanol supplementation affect muscular strength during the 9-week resistance training?

3. Does 600mg/day gamma oryzanol supplementation affect blood lipid profile during the 9-week resistance training?

4. Does 600mg/day gamma oryzanol supplementation affect serum minerals concentrations during the 9-week resistance training?

5. How does 600mg/day gamma oryzanol supplementation influence post-exercise and resting levels of anabolic and catabolic hormones during the 9-week resistance training?

6. How does 600mg/day gamma oryzanol supplementation influence post-exercise and resting levels of circulating binding proteins during the 9-weeks resistance training?

7. How does 600mg/day gamma oryzanol supplementation influence post-exercise and resting ratios of free testosterone to cortisol and total testosterone to SHBG during the 9-week resistance training?

1.3 Significance of the Study

Many strength-trained athletes, in order to overcome genetic limitations in hormonal status, have consumed exogenous anabolic/androgenic steroids (AAS) impressively to increase muscle growth and strength, especially testosterone, and many athletes consider AAS as a principle element for success (Smith & Perry, 1992). Even so, the

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use of AAS has been linked to a variety of health problems and disorders; some of them are irreversible. Consequently, the focus on nutrient supplementation has been expanded as a substitute to elevate muscular mass and strength (Cowart, 1992). One of the safe, herbal and nutritious sports supplement is gamma oryzanol. In fact, gamma oryzanol was the first herbal derivative with examined anabolic impact as a natural substitute of synthetic anabolic steroids. Gamma oryzanol seems to be nontoxic (Talbott, 2003). Side effects have not been reported in animal studies using doses of up to 1000 to 1500 mg per day of gamma oryzanol. Poor absorption accounts for the cause of the shortage of side effects related to higher doses (Talbott, 2003).

There is very limited number of studies investigating gamma oryzanol effects on improving effective factors in resistance training. In fact, more information is needed to prove the suggested effects of gamma oryzanol on resistance training. In other words, the anabolic effects of gamma oryzanol need to be confirmed by several researches and then it could be used as a substitute for anabolic steroids and other harmful drugs and supplements. Therefore, a better understanding of gamma oryzanol effects on different influencing factors on resistance training might be essential to increase the effectiveness and improving exercise performance through a safe and nutritious way.

The finding of this study can contribute to the growing body of research of sport supplements and ergogenic aids by providing valuable knowledge and in depth information on this healthy herbal supplement. Also, this study will give further insight to determine the effect of gamma oryzanol supplementation on post-exercise and resting levels of anabolic and catabolic hormones, lipid profile, anthropometric

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and muscular strength alterations as well as mineral changes. In addition, this study is a pioneer study to test the effects of gamma oryzanol supplementation during resistance training in untrained young males on comprehensive influencing and contributing factors, comprising anthropometric and muscular strength, endocrine changes through measuring different hormones, lipid profile and mineral concentrations. The results of the investigation may indicate whether the supplementation of gamma oryzanol is beneficial to resistance training in untrained healthy males.

1.4 Limitations

The following limitations of the study were noted:

1. The resistance workout may have differed from what the subjects were accustomed to doing. The baseline period may not have been long enough to completely familiarize the subjects with the workout. Some learning effect may have been occurring even at the end of the study.

2. Subjects were not continuously monitored to see if they were stringently adhering to the study's dietary and resistance training guidelines. The assumption of this study for physical activity level and dietary pattern of subjects was based on their attending in resistance training sessions and having similar dietary and physical activity, as they all have lived in dormitories and they have been feed by the dormitories restaurant.

3. The length of resistance training (9 weeks) might be enough to make any changes for anthropometric measurements, as in several studies eight weeks

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masses. To do so, subjects performed 6 sets of 10 repetitions with 80% 1-RM. The exercises used for the AHRE were free weight, except the lateral pull downs, which was performed using a universal weight machine. Resistance training was performed four times a week, performing 3 sets per exercise for a period of 9 weeks for each participant. The exercises used for the resistance training program were free weight, except the lateral pull downs, which was performed using a universal weight machine.

3. Anthropometric measurements, muscular strength, lipid profile and mineral concentration have been measured at the commencement day and the end of the study.

4. Hormonal variation has been measured four times; at baseline, immediately after AHRE, at the end of the 9-week following AHRE, and finally 24 hours after recovery. The assessment was limited to monitor these alterations before and after resistance exercise and finally 24 hours, in recovery condition, as it was intended to make less suffering for the participants.

5. The independent variables were a carbohydrate beverage (1g/kg of body weight) for the carbohydrate group and an artificially sweetened beverage for the placebo group. The control group did not undergo energy restriction or receive a beverage prior to the last performance test. To control dietary changes and supplement compliance during the study, a 24-hour dietary recall was used, including two non-consecutive weekdays and one weekend day.

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1.6 Conceptual Framework

In this study, the effects of gamma oryzanol supplementation with resistance exercise on some dependent variables were investigated, as shown in Figure 1.1. Dependent variables were body measurements, muscular strength, lipid profile, concentrations of anabolic/catabolic hormones and serum minerals. The intervener variables, including sex, age, consumption of supplements and chronic diseases were controlled as they are explained in methodology. In this study, gamma oryzanol supplementation during resistance training is viewed as being effective on multiple physiological aspects, consisting body measurements, muscular strength, anabolic/catabolic hormones levels, blood lipid profile and serum mineral concentrations.

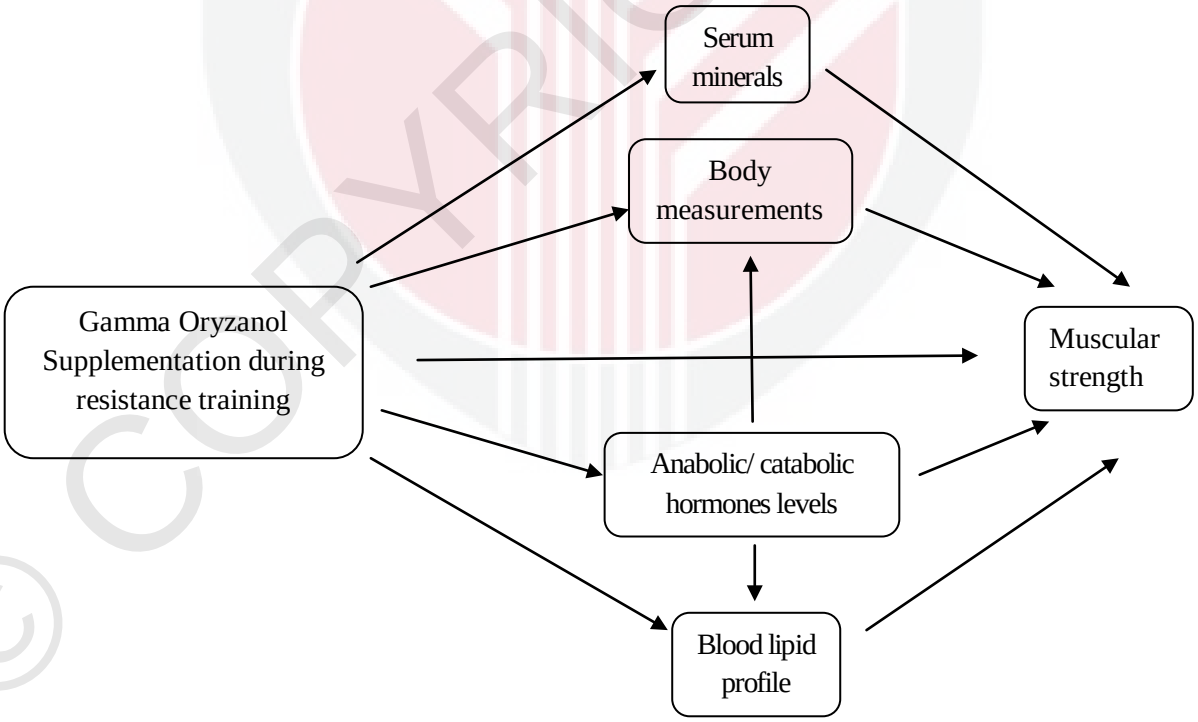

Figure 1.1 Conceptual Framework

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1.7 Objectives

1.7.1 General Objective

To study the effects of 600 mg/day gamma oryzanol supplementation on lipid profile, anabolic/catabolic hormones, circulating binding proteins and anthropometric changes in young males during a 9-week resistance training

1.7.2 Specific Objectives

These are the following objectives that the research would like to achieve.

1. To assess effects of 600mg/day gamma oryzanol supplementation during 9 weeks of resistance training on changes in skin fold thickness, weight, waist and hip, thigh, arm circumference, shoulder and pelvis width and body mass index (BMI)

2. To assess effects of 600mg/day gamma oryzanol supplementation during 9 weeks of resistance training on changes in muscular strength

3. To assess effects of 600mg/day gamma oryzanol supplementation during 9 weeks of resistance training on changes in blood lipid profile (total cholesterol [TC], triglycerides [TG], low density lipoprotein cholesterol [LDL-C], high density lipoprotein cholesterol [HDL-C] and very low density lipoprotein cholesterol [VLDL-C])

4. To assess effects of 600mg/day gamma oryzanol supplementation during 9 weeks of resistance training on changes in serum concentrations of copper, zinc, calcium and magnesium

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5. To assess effects of 600mg/day gamma oryzanol supplementation during 9 weeks of resistance training on changes in circulating concentrations of hormones (testosterone [free testosterone and total testosterone], dehydroepiandrosterone sulfate (DHEAS), cortisol, estradiol, GH, thyroxin T4), triiodothyronine (T3), thyroid stimulating hormone (TSH), insulin-like growth-factor I (IGF-I), insulin, epinephrine and norepinephrine

6. To assess effects of 600mg/day gamma oryzanol supplementation during 9 weeks of resistance training on changes in circulating binding proteins (albumin, sex hormone binding globulin [SHBG] and insulin-like growth-factor binding protein 3 [IGFBP3])

7. To assess effects of 600mg/day gamma oryzanol supplementation during 9 weeks of resistance training on changes in ratios of free testosterone to cortisol and total testosterone to SHBG

1.8 Hypothesis

H_0 1: There was no significant difference in anthropometric measurements between the supplement and placebo groups following the 9-week resistance training.

H_0 2: There was no significant difference in muscular strength between the supplement and placebo groups following the 9-week resistance training.

H_0 3: There was no significant difference in lipid profile between the supplement and placebo groups following the 9-week resistance training.

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H_0 4: There was no significant difference in serum mineral concentrations between the supplement and placebo groups following the 9-week resistance training.

H_0 5: There was no significant difference in circulating concentrations of anabolic and catabolic hormones between the supplement and placebo groups following the 9-week resistance training.

H_0 6: There was no significant difference in circulating binding proteins levels between the supplement and placebo groups following the 9-week resistance training.

H_0 7: There was no significant difference in ratios of free testosterone to cortisol and total testosterone to SHBG between the supplement and placebo groups following the 9-week resistance training.

1.9 Definition of Terms

1.9.1 Resistance Training

Resistance training is a form of strength training in which each effort is performed against a specific opposing force generated by resistance (i.e. resistance to being pushed, squeezed, stretched or bent). Exercises are isotonic if a body part is moving against the force. Exercises are isometric if a body part is holding still against the force. Resistance exercise is used to develop the strength and size of skeletal muscles. Properly performed, resistance training can provide significant functional benefits and improvement in overall health and well-being.

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The goal of resistance training, according to the American Sports Medicine Institute (ASMI), is to "gradually and progressively overload the musculature system so it gets stronger. Resistance training works to increase muscle strength and endurance by doing repetitive exercises with weights, weight machines, or resistance bands.

1.9.2 Anthropometric measurements

Tests of anthropometry include measurements of body size, structure, and composition. It is important to be aware of the effects of changes to these factors, and to be able to measure them. For most sports body size is an important factor in success, whether it is advantageous to be short, tall, heavy or light. The body composition, such as the amount of body fat and muscle mass, can also significantly affect sporting performance. Body composition refers primarily to the distribution of muscle and fat in the body, and its measurement plays an important role in both sports and health. In sports, excess fat hinders performance as it does not contribute to muscular force production, and it is additional weight that requires energy to move about.

Body fat is commonly assessed by skinfold thickness. This is an estimated measure of subcutaneous fat. Body size refers to the volume, mass, length and surface area of the body, while body composition refers to the amounts of these constituents of the body. Body size and structure measurements can be used for monitoring growth patterns and changes with training, and for identifying appropriate sports for individuals.

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1.9.3 Lipid profile

Lipid profile or lipid panel, is the collective term given to the estimation of, typically, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triglycerides. An extended lipid profile may include very low-density lipoprotein. This is used to identify hyperlipidemia (various disturbances of cholesterol and triglyceride levels), many forms of which are recognized risk factors for cardiovascular disease and sometimes pancreatitis.

1.9.4 Anabolic and catabolic hormones

Anabolism is the set of metabolic pathways that construct molecules from smaller units. One way of categorizing metabolic processes, whether at the cellular, organ or organism level is as 'anabolic' or as 'catabolic', which is the opposite. Anabolism is powered by catabolism, where large molecules are broken down into smaller parts and then used up in respiration. Anabolic processes tend toward "building up" organs and tissues. These processes produce growth and differentiation of cells and increase in body size, a process that involves synthesis of complex molecules. Examples of anabolic processes include the growth and mineralization of bone and increases in muscle mass. Endocrinologists have traditionally classified hormones as anabolic or catabolic, depending on which part of metabolism they stimulate. The classic anabolic hormones are the anabolic steroids, which stimulate protein synthesis and muscle growth. The so-called classic catabolic hormones known since the early 20th century are cortisol, catecholamines (epinephrine and norepinephrine).

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1.9.5 One- repetition maximum (1-RM)

One repetition maximum (1-RM) in weight training is the maximum amount of weight one can lift in a single repetition for a given exercise. One repetition maximum can be used for determining an individual's maximum strength and is the method for determining the winner in events such as powerlifting and weightlifting competitions. One repetition maximum can also be used as an upper limit, in order to determine the desired "load" for an exercise (as a percentage of the 1-RM).

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REFERENCES

Aagaard, P. (2004). Making muscles "stronger": Exercise, nutrition, drugs. *J Musculoskel Neuron Interact, 4*(2), 165-174.

Abe, T., DeHoyos, D. V., Pollock, M. L., & Garzarella, L. (2000). Time course for strength and muscle thickness changes following upper and lower body resistance training in men and women. *European Journal of Applied Physiology, 81*(3), 174-180.

Adlercreutz, H., Harkonen, M., Kuoppasalmi, K., et al. (1986). Effect of training on plasma anabolic and catabolic steroid hormones and their responses during physical exercise. *International Journal of Sports Medicine, 7(supplement)*, 27-28.

Ahtiainen, J., Pakarinen, A., Alen, M., Kraemer, W., & Häkkinen, K. (2003). Muscle hypertrophy, hormonal adaptations and strength development during strength training in strength-trained and untrained men. *European Journal of Applied Physiology, 89*(6), 555-563.

Aizawa, K., Akimoto, T., Inoue, H., Kimura, F., Joo, M., Murai, F., et al. (2003). Resting serum dehydroepiandrosterone sulfate level increases after 8-week resistance training among young females. *European Journal of Applied Physiology, 90*(5), 575-580.

Alan, A., Pakarinen, A., Hakkinen, K., & Komi, P. (1988). Responses of serum androgenic-anabolic and catabolic steroidhormones to prolonged strength training. *International Journal of Sports Medicine, 9*, 229-233.

Alen , M., Pakarinen, A., & Häkkinen, K. (1993). Effects of prolonged training on serum thyrotropin and thyroid hormones in elite strength athletes. *Journal of Sports Sciences, 11*(6), 493 - 497.

Baumgartner, R., Koehler, K., Romero, L., & Garry, P. (1996). Serum albumin is associated with skeletal muscle in elderly men and women. *American Journal of Clinical Nutrition, 64*(4), 552-558.

Bent, S. (2008). Herbal medicine in the United States: Review of efficacy, safety, and regula-tion: Grand Rounds at University of California, San Francisco Medical Center. . *Journal of General Internal Medicine, 23*, 854-859.

Bent, S., & Ko, R. (2004). Commonly used herbal medicines in the United States: a review. *Am J Med, 116*, 478-485.

Berger, A., Rein, D., Schäfer, A., Monnard, I., Gremaud, G., Lambelet, P., et al. (2005). Similar cholesterol-lowering properties of rice bran oil, with varied ɣoryzanol, in mildly hypercholesterolemic men. *European Journal of Nutrition, 44*, 163-173.

© COPYRIGHT UPM

Berger, A., Rein, D. Schäfer, A., Monnard, I., Gremaud, G., Lambelet, P., Bertoli, C. (2005). Similar cholesterol–lowering properties of rice bran oil, with varied γ–oryzanol, in mildly hypercholesterolemic men. *European Journal of Nutrition, 44*(3), 163-173.

Bernstein , A., Safirstein, J., & Rosen, J. E. (2003). Athletic Ergogenic Aids. *Bull Hosp Jt Dis, 61*(3-4), 164-171.

Blumenthal, M., Ferrier, G. K. L., & Cavaliere, C. (2006). Total sales of herbal supplements inthe United States show steady growth. *HerbalGram, 71*, 64-66.

Boardley, D., Fahlman, M., Topp, R., Morgan, A. L., & McNevin, N. (2007). The Impact of Exercise Training on Blood Lipids in Older Adults. *The American Journal of Geriatric Cardiology, 16*(1), 30-35.

Borsheim, E., Cree, M. G., Tipton, K. D., Elliott, T. A., Aarsland, A., & Wolfe, R. R. (2004). Effect of carbohydrate intake on net muscle protein synthesis during recovery from resistance exercise. *Journal of Applied Physiology, 96*(2), 674-678.

Borst , S. E., De Hoyos, D. V., Garzarella, L., Vincent, K., Pollock, B. H., Lowenthal, D. T., et al. (2001). Effects of resistance training on insulin-like growth factor-I and IGF binding proteins. *Medical Science Sports Exercise, 33*, 648-653.

Bottaro, M., Martins, B., Gentil, P., & Wagner, D. (2009). Effects of rest duration between sets of resistance training on acute hormonal responses in trained women. *Journal of Science and Medicine in Sport, 12*(1), 73-78.

Boyden, T. W., Pamenter, R. W., Going, S. B., Lohman, T. G., Hall, M. C., Houtkooper, L. B., et al. (1993). Resistance Exercise Training Is Associated With Decreases in Serum Low-Density Lipoprotein Cholesterol Levels in Premenopausal Women. *Archives of Internal Medicine, 153*(1), 97-100.

Braith, R. W., & Stewart, K. J. (2006). Resistance Exercise Training: Its Role in the Prevention of Cardiovascular Disease. *Circulation, 113*(22), 2642-2650.

Bran, S., Rice, H., Extract, H., Extract, O., Powder, O., Starch, O., et al. (2006). Amended Final Report on the Safety Assessment of Oryza Sativa (Rice) Bran Oil, Oryza Sativa (Rice) Germ Oil, Rice Bran Acid, Oryza Sativa (Rice) Bran Wax, Hydrogenated Rice Bran Wax, Oryza Sativa (Rice) Bran Extract, Oryza Sativa (Rice) Extract, Oryza Sativa (Rice) Germ Powder, Oryza Sativa (Rice) Starch, Oryza Sativa (Rice) Bran, Hydrolyzed Rice Bran Extract Hydrolyzed Rice Bran Protein, Hydrolyzed Rice Extract, and Hydrolyzed Rice Protein. *International Journal of Toxicology, 25*(2 suppl), 91.

Bruni , J. (1988). *Gamma oryzanol: The facts*. New York: New York University.

Bucci , L. A. (1989). *Natural magic bullet? Flex Februrary*.

© COPYRIGHT UPM

Buchman, A. L., Keen, C., Commisso, J., Killip, D., Ou, C.-N., Rognerud, C. L., et al. (1998). The Effect of a Marathon Run on Plasma and Urine Mineral and Metal Concentrations. *Journal of the American College of Nutrition, 17*(2), 124-127.

Burke, L., Desbrow, B., & Minehan, M. (2000). Dietary supplements and nutritional ergogenic aids in sport. In L. Burke & V. Deakin (Eds.), *Clinical Sports Nutrition* (pp. 455-553). sydney: McGraw-Hill.

Campbell, W. W., & Anderson, R. A. (1987). Effects of Aerobic Exercise and Training on the Trace Minerals Chromium, Zinc and Copper. *Sports Medicine, 4*(1), 9-18.

Cardone, A., Angelini, F., Esposito, T., Comitato, R., & Varriale, B. (2000). The expression of androgen receptor messenger RNA is regulated by tri-iodothyronine in lizard testis. *The Journal of Steroid Biochemistry and Molecular Biology, 72*(3-4), 133-141.

Cardoso, C. G., Gomides, R. S., Queiroz, A. C., Pinto, L. G., da Silveira Lobo, F., Tinucci, T., et al. (2010). Acute and chronic effects of aerobic and resistance exercise on ambulatory blood pressure *CLINICS, 65*(3), 317-325.

Chandler, R., Byrne, H., Patterson, J., & Ivy, J. (1994). Dietary supplements affect the anabolic hormones after weight-training exercise. *Journal of Applied Physiology, 76*(2), 839.

Chausmer, A. B. (1998). Zinc, Insulin and Diabetes. *J Am Coll Nutr, 17*(2), 109-115.

Child, P. (1986). The absorption of cholesterol and plant sterols by the intestine. In Kusis A (Ed.), *Fat Absorption*. Boca Raton, FL: CRC Press.

Cicero, A. F., & Gaddi, A. (2001). Rice bran oil and gamma-oryzanol in the treatment of hyperlipoproteinaemias and other conditions. *Phytotherapy Research, 15*, 277-289.

Copeland, J. L., & Heggie, L. (2008). IGFâ€ I and IGFBP -3 during Continuous and Interval Exercise. *International Journal of Sports Medicine, 29*(03), 182,187.

Covinsky, K. E., Covinsky, M. H., Palmer, R. M., & Sehgal, A. R. (2002). Serum Albumin Concentration and Clinical Assessments of Nutritional Status in Hospitalized Older People: Different Sides of Different Coins? *Journal of the American Geriatrics Society, 50*(4), 631-637.

Cowart, V. (1992). Dietary supplements: Alternatives to anabolic steroids? *Physician and Sportsmedicine, 20*, 189-198.

Crewther, B., Keogh, J., Cronin, J., & Cook, C. (2006). Possible stimuli for strength and power adaptation: acute hormonal responses. *Sports Medicine, 36*(3), 215-238.

© COPYRIGHT UPM

Danforth, E., & Burger, A. G. (1989). The Impact of Nutrition on Thyroid Hormone Physiology and Action. *Annual Review of Nutrition, 9*(1), 201-227.

de Oliveira, K. d. J. F., Donangelo, C. M., de Oliveira, A. V., da Silveira, C. L. P., & Koury, J. C. (2009). Effect of zinc supplementation on the antioxidant, copper, and iron status of physically active adolescents. *Cell Biochemistry and Function, 27*(3), 162-166.

De Smet, P. A. G. M. (2005). Herbal medicine in Europe-Relaxing regulatory standards. *The New England Journal of Medicine, 352*, 1176-1178.

Deschenes, M. R., Kraemer, W. J., Bush, J. A., Douphty, T. A., Kim, D., Mullen, K. M., et al. (1998). Biorhytmic influences on functional capacity of human muscle and physiological responses. *Medical Science Sports Exercise, 30*(9), 1399-1407.

Dibley, M. J. (2006). Zinc. In B. A. Brown Bowman & R. M. Russell (Eds.), *Present knowledge in nutrition* (Vol. 2). Washington, D.C.: ILSI Press, International Life Sciences Institute.

Dioum , A., Gartner , A., Maire , B., Delpeuch , F., & Wade , S. (2005). Body composition predicted from skinfolds in African women: a cross-validation study using air-displacement plethysmography and a black-specific equation. *British Journal of Nutrition, 93*, 973-979.

Douglas, B. (2001). *Effective strength training : analysis and technique for upper-body, lower-body, and trunk exercises* Champaign, IL: Human Kinetics.

Doweiko, J. P., & Nompleggi, D. J. (1991). Reviews: Role of Albumin in Human Physiology and Pathophysiology. *Journal of Parenteral and Enteral Nutrition, 15*(2), 207-211.

Dressendorfer, R. H., Wade, C. E., Keen, C. L., & Scaff, J. H. (1982). Plasma mineral levels in marathon runners during a 20-day road race. *Physician and Sportsmedicine, 10*, 113-118.

Durnin, J., & Womersley, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *British Journal of Nutrition, 32*(01), 77-97.

Elliott, K. J., Sale, S., & Cable, N. T. (2002). Effects of resistance training and detraining on muscle strength and blood lipid profiles in postmenopausal women. *British Journal Sports Medicine, 36*(5), 340-344.

Elloumi , M., El Elj, N., Zaouali, M., Maso, F., Filaire, E., Tabka, Z., et al. (2005). IGFBP-3, a sensitive marker of physical training and overtraining. *British Journal Sports Medicine 39*, 604-610.

Ervin , R., Wright, J., & Reed-Gillette, D. (2004). Prevalence of leading types of dietary supplements used in the Third National Health and Nutrition Examination Survey, 1988-1994. *Advance Data, 9*(349), 1-7.

© COPYRIGHT UPM

Excoffon, L., Guillaume, Y. C., Woronoff-Lemsi, M. C., & André, C. (2009). Magnesium effect on testosterone-SHBG association studied by a novel molecular chromatography approach. *Journal of Pharmaceutical and Biomedical Analysis, 49*(2), 175-180.

Fahey, T. D., Rolph, R., Moungmee, P., Nadel, J., & Martara, S. (1976). Serum testosterone, body composition, and strength of young adults. *Medicine & Science in Sports & Exercise, 8*, 31-34.

Fang, N., Yu, S., & Badger, T. M. (2003). Characterization of Triterpene Alcohol and Sterol Ferulates in Rice Bran Using LC-MS/MS. *Journal of Agricultural and Food Chemistry, 51*(11), 3260-3267.

Fedele, M. J., Lang, C. H., & Farrell, P. A. (2001). Immunization against IGF-I prevents increases in protein synthesis in diabetic rats after resistance exercise. *Am J Physiol Endocrinol Metab, 280*(6), E877-885.

Fenkci, S., Sarsan, A., Rota, S., & Ardic, F. (2006). Effects of resistance or aerobic exercises on metabolic parameters in obese women who are not on a diet. *Advances in Therapy, 23*(3), 404-413.

Ferrucci, L., Penninx, B. W. J. H., Leveille, S. G., Corti, M.-C., Pahor, M., Wallace, R., et al. (2000). Characteristics of nondisabled older persons who perform poorly in objective tests of Lower extremity function. *Journal of the American Geriatrics Society, 48*(9), 1102-1110.

Fleck, S. J., & Kraemer, W. J. (2004). *Designing resistance training programs* (3rd ed.). Champaign, Ill. ; Leeds: Human Kinetics.

Florian, B., Mélissa, L., Abdelouahed, K., & Isabelle, J. D. (2009). Effect of Resistance Training on Hematological Blood Markers in Older Men and Women: A Pilot Study. *Current Gerontology and Geriatrics Research, 2009*, 1-4.

Florini, J. R. (1987). Hormonal control of muscle growth. *Muscle Nerve, 10*, 577-598.

Fortunati, N., Catalano, M., Boccuzzi, G., & Frairia, R. (2010). Sex Hormone-Binding Globulin (SHBG), estradiol and breast cancer. *Molecular and cellular endocrinology, 316*(1), 86-92.

French, D. N., Kraemer, W. J., Volek, J. S., Spiering, B. A., Judelson, D. A., Hoffman, J. R., et al. (2007). Anticipatory responses of catecholamines on muscle force production. *Journal of Applied Physiology, 102*(1), 94-102.

Froiland, K., Koszewski, W., Hingst, J., & Kopecky, L. (2004). Nutritional supplement useamong college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism, 14*, 104-120.

© COPYRIGHT UPM

Fry, A. C., Bonner, E., Lewis, D. L., Johnson, R. L., Stone, M. H., & Kraemer, W. J. (1997). The effects of gamma-oryzanol supplementation during resistance exercise training. *International Journal of Sport Nutrition, 7*, 318-329.

Fry , A. C., & Kraemer, W. J. (1997). Resistance exercise overtraining and overreaching: neuroendocrine responses. *Sports Medicine, 23*(2), 106-129.

Fry , A. C., Kraemer , W. J., & Ramsey, L. T. (1998). Pituitary-adrenal-gonadal responses to high-intensity resistance exercise overtraining. *Journal of Applied Physiology, 85*, 2352-2359.

Gartner, A., Dioum, A., Delpeuch, F., Maire, B., & Schutz, Y. (2004). Use of hand-to-hand impedancemetry to predict body composition of African women as measured by air displacement plethysmography. *European Journal of Clinical Nutrition, 58*(3), 523-531.

Ghaffarpour , M., Houshiar-Rad , A., & Kianfar , H. (1999). *The manual for household measures, cooking yields factors and Edible portion of food*. Tehran: Keshavarzi Press.

Gobbo, L., Ritti-Dias, R., Avelar, A., & Silva, A. (2012). Changes in Skeletal Muscle Mass Assessed by Anthropometric Equations after Resistance Training. *International Journal of Sports Medicine.*

Godber , J., Xu, Z., Hegsted , M., & Walker , T. (2002). Rice and rice bran oil in functional foods development. *Louisiana Agriculture, 45*(4), 9-10.

Godfrey, R. J., Madgwick, Z., & Whyte, G. P. (2003). The Exercise-Induced Growth Hormone Response in Athletes. *Sports Medicine, 33*, 599-613.

Goldberg , L., Elliot , D. L., & Schutz , R. W., et al. (1984). Changes in lipid and lipoprotein levels after weight training. *Journal of the American Medical Association, 252*, 504-506.

Gonza´lez-Badillo, J. J., Gorostiaga, E. M., Arellano, R., & Izquierdo, M. (2005). Moderate resistance training volume produces more favorable strength gains than high or low volumes. *The Journal of Strength & Conditioning Research, 19*, 689-697.

Goto, S., & Radak, Z. (2005). Proteins and exercise. In F. C. Mooren & K. Volker (Eds.), *Molecular and cellular exercise physiology*. Champaign, Ill: Human Kinetics.

Guezennec, Y., Leger, L., Lhoste, F., Aymonod, M., & Pesquies, P. C. (1986). Hormone and Metabolite Response to Weight-Lifting Training Sessions. *International Journal of Sports Medicine, 07*(02), 100,105.

Hahlbrock, K., & Grisebach, H. (1979). Enzymic controls in the biosynthesis of lignin and flavonoids. *Annual Review of Plant Physiology, 30*(1), 105-130.

© COPYRIGHT UPM

Häkkinen , K. (1989). Neuromuscular and hormonal adaptations during strength and power training *The Journal of Sports Medicine and Physical Fitness, 29*, 9-24.

Häkkinen, K., Pakarinen, A., Alen, M., Kauhanen, A., & Komi, P. V. (1988a). Daily hormonal and neuromuscular responses to intensive strength training in 1 week. *International Journal of Sports Medicine, 9*, 422-428.

Häkkinen, K., Pakarinen, A., Alen, M., Kauhanen, A., & Komi, P. V. (1988b). Neuromuscular and hormonal adaptations in athletes to strength training in two years. *Journal of Applied Physiology, 65*, 2406-2412.

Häkkinen , K., Pakarinen, A., Alen, M., Kauhanen, M., & Komi, P. V. (1987). Relationships between training volume, physical performance capacity, and serum hormone concentrations during prolonged training in elite weight lifters. *International Journal Sports Medicine Supplement, 8*, 61-65.

Häkkinen , K., Pakarinen, A., Kraemer, W. J., Newton, R. U., & Alen, M. (2000). Basal concentrations and acute responses of serum hormones andstrength development during heavy resistance training in middle-aged andelderly men and women. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 55*(2), B95-105.

Häkkinen , K., Pakarinen, A., Kyröläinen, H., Cheng, S., Kim, D. H., & Komi, P. V. (1990). Neuromuscular adaptations and serum hormones in females during prolonged power training. *International Journal of Sports Medicine, 11*(2), 91-98.

Häkkinen, K., Pakarinen, A. (1995). Acute hormonal responses to heavy resistance exercise in men and women at different ages. *International Journal of Sports Medicine, 16*, 507-513.

Hammond, G. L. (1995). Potential functions of plasma steroid-binding proteins. *Trends in Endocrinology and Metabolism, 6*(9-10), 298-304.

Hammond, G. L., & Bocchinfuso, W. P. (1995). Sex hormone-binding globulin/androgen-binding protein: Steroid-binding and dimerization domains. *The Journal of Steroid Biochemistry and Molecular Biology, 53*(1-6), 543-552.

Hanmoungjai, P., Pyle, D., & Niranjan, K. (2002). Enzyme-assisted water-extraction of oil and protein from rice bran. *Journal of Chemical Technology and Biotechnology, 77*, 771-776.

Harrison, R. A., Holt, D., Pattison, D. J., & Elton, P. J. (2004). Who and how many people are tak-ing herbal supplements? A survey of 21,923 adults. *International Journal of Vitamin & Mineral Research, 74*, 183-186.

Hiramatsu , K., Tani , T., Kimura , Y., Izumi , S., & Natane , P. K. (1990). Effect of gamma oryzanol on atheroma formation in hypercholesterolemic rabbits. *Tokai Journal of Experimental and Clinical Medicine, 15*, 299-305.

© COPYRIGHT UPM

Hoeger, W. W. K., & Hoeger, S. A. (2008). *Principles and labs for physical fitness* (6th ed.). Belmont, CA, Australia: Thomson/Wadsworth,.

Hoffman, J. R. (2002). *Physiological aspects of sport training and performance*. Champaign, Il [u.a.]: Human Kinetics.

Hoogeven, A. R., & Zonderland, M. L. (1996). Relationships between testosterone, cortisol and performance in professional cyclists. *International Journal of Sports Medicine, 17*, 423-428.

Hopkins, W. G., Hawley, J. A., & Burke, L. M. (1999). Design and analysis of research on sport performance enhancement. *Medicine & Science in Sports & Exercise, 31*(3), 472-485.

Houlihan, B. (2002). *Dying to win : doping in sport and the development of anti-doping policy*. Strasbourgh: Council of Europe Publishing.

Hurley, B. F., Hagberg, J.M., Goldberg, A.P., et al. (1988). Resistive training can reduce coronary risk factors without altering V~O2MAX or percent body fat. *Medical Science Sports Exercise, 20*, 150-154.

Ishihara, M., Ito, Y., Nakakita, T., Maehama, T., Hieda, S., Yamamoto, K., et al. (1982). Clinical effect of gamma-oryzanol on climacteric disturbance -on serum lipid peroxides. *Nippon Sanka Fujinka Gakkai Zassh, 34*(2), 243-251.

Izquierdo , M., Ibañez , J., Calbet , J., Navarro-Amezqueta , I., González-Izal , M., Idoate , F., et al. (2009). Cytokine and hormone responses to resistance training. *European Journal of Applied Physiology, 107*(4), 397-409.

Jackson, R. C. G. (2001). *Nutrition and the strength athletes*. Florida: CRC Press.

Joseph, L. J. O., Davey, S. L., Evans, W. J., & Campbell, W. W. (1999). Differential effect of resistance training on the body composition and liporotein-lipid profile in older men and women. *Metabolism, 48*(11), 1474-1480.

Kahn, S., Hryb, D., Nakhla, A., Romas, N., & Rosner, W. (2002). Sex hormone-binding globulin is synthesized in target cells. *Journal of Endocrinology, 175*(1), 113-120.

Kaneko, R., & Tsuchiya, T. (1955). *New compound in rice bran and germ oils.*

Katznelson, L., Robinson, M. W., Coyle, C. L., Lee, H., & Farrell, C. E. (2006). Effects of modest testosterone supplementation and exercise for 12 weeks on body composition and quality of life in elderly men. *European Journal of Endocrinology, 155*(6), 867-875.

Kelley, G. A., & Kelley, K. S. (2009). Impact of progressive resistance training on lipids and lipoproteins in adults: A meta-analysis of randomized controlled trials. *Preventive Medicine, 48*(1), 9-19.

© COPYRIGHT UPM

Kelly, A., Lyongs, G., Gambki, B., & Robinstein, N. (1985). Influences testosterone on contractile proteins of the guinea pig temporalis muscle. *Advances in Experimental Medicine and Biology, 182*, 155-168.

Kendall , B., & Eston , R. (2002). Exercise-induced muscle damage and the potential protective role of estrogen. *Sports Medicine, 32*, 103-123.

Kerckhoffs, D. A. J. M., Brouns, F., Hornstra, G., & Mensink, R. P. (2002). Effects on the Human Serum Lipoprotein Profile of {beta}-Glucan, Soy Protein and Isoflavones, Plant Sterols and Stanols, Garlic and Tocotrienols. *Journal of Nutrition, 132*(9), 2494-2505.

Kikuzaki, H. (2002). Antioxidant properties of ferulic acid and its related compounds. *Journal of Agricultural and Food Chemistry, 50*(7), 2161-2168.

King, D. S., Sharp, R. L., Vukovich, M. D., Brown, G. A., Reifenrath, T. A., Uhl, N. L., et al. (1999). Effect of Oral Androstenedione on Serum Testosterone and Adaptations to Resistance Training in Young Men: A Randomized Controlled Trial. *Journal of the American Medical Association, 281*(21), 2020-2028.

Koistinen , H., Koistinen, R., Selenius, L., Ylikorkala, Q., & Seppala, M. (1996). Effect of marathon run on serum IGF-I and IGF-binding protein 1 and 3 levels. *Journal of Applied Physiology, 80*(3), 760-764.

Kokkinos , P. F., Hurley, B. F., Smutok, M. A., Farmer, C., Reece, C., Shulman, R., et al. (1991). Strength training does not improve lipoprotein-lipid profiles in men at risk for CHD. *Medicine & Science in Sports & Exercise, 23*(10), 1134-1139.

Kokkinos , P. F., Hurley, B. F., Vaccaro, P., Patterson, J. C., Gardner, L. B., Ostrove, S. M., et al. (1988). Effects of low- and high-repetition resistive training on lipoprotein-lipid profiles. *Medicine & Science in Sports & Exercise, 20*(1), 50-54.

König, D., Keul, J., Northoff, H., & Berg, A. (1997). Rationale for a specific diet from the perspective of sports medicine and sport orthopedics and its relation to stress reactions and regeneration. *Der Orthopäde, 26*(11), 942-950.

Koury, J. C., Oliveira, A. V., Portella, E. S., Oliveira, C. F., Lopes, G. C., & Donangelo, C. M. (2004). Zinc and copper biochemical indices of antioxidant status in elite athletes of different modalities. *International Journal of Sport Nutrition and Exercise Metabolism, 14*, 358-372.

Koziris, L. P., Hickson, R. C., Chatterton, R. T., Jr., Groseth, R. T., Christie, J. M., Goldflies, D. G., et al. (1999). Serum levels of total and free IGF-I and IGFBP-3 are increased and maintained in long-term training. *Journal of Applied Physiology, 86*(4), 1436-1442.

Kraemer, W. J., Aguilera, B. A., Terada, M., Newton, R. U., Lynch, J. M., Rosendaal, G., et al. (1995). Responses of IGF-I to endogenous increases in

© COPYRIGHT UPM

growth hormone after heavy-resistance exercise. *Journal of Applied Physiology, 79*(4), 1310.

Kraemer , W. J., Dziados, J. E., Marchitelli, L. J., Gordon, S. E., Harman, E. A., Mello, R., et al. (1993). Effects of different heavy resistance exercise protocols on plasma B-endorphin concentrations. *Journal of Applied Physiology, 74*(1), 450-459.

Kraemer, W. J., Fleck, S. J., Dziados, J. E., Harman, E. A., Marchitelli, L. J., Gordon, S. E., et al. (1993). Changes in hormonal concentrations after different heavy-resistance exercise protocols in women. *Journal of Applied Physiology, 75*(2), 594.

Kraemer , W. J., Fleck, S. J., Maresh, C. M., Ratamess, N. A., Gordon, S. E., Goetz, K. L., et al. (1999). Acute hormonal responses to a single bout of heavy resistance exercise in trained power lifters and untrained men. *Applied Physiology, Nutrition, and Metabolism, 24*(6), 524-537.

Kraemer , W. J., Fry , A. C., Warren , B. J., Stone, M. H., Fleck, S. J., Keamey, J. T., et al. (1992). Acute hormonal responses in elit junior weightliftres. *International Journal of Sports Medicine, 13*(2), 103-109.

Kraemer, W. J., Häkkinen, K., Newton, R. U., Nindl, B. C., Volek, J. S., McCormick, M., et al. (1999). Effects of heavy resistance training on hormonal responses patterns in younger vs. older men. *Journal of Applied Physiology, 87*, 982-992.

Kraemer, W. J., Marchitelli, L., Gordon, S. E., Harman, E., Dziados, J. E., Mello, R., et al. (1990). Hormonal and growth factor responses to heavy resistance exercise protocols. *Journal of Applied Physiology, 69*(4), 1442-1450.

Kraemer, W. J., Noble, B., Culver, B., & Lewis, R. V. (1985). Changes in plasma proenkephalin peptide F and catecholamine levels during graded exercise in men. *Proceedings of the National Academy of Sciences of the United States of America, 82*(18), 6349-6351.

Kraemer, W. J., Noble, B. J., Clark, M. J., & Culver, B. W. (1987). Physiological responses to heavy-resistance exercise with very short rest periods. *International Journal of Sports Medicine, 8*, 247-252.

Kraemer, W. J., & Ratamess, N. A. (2003). Endocrine responses and adaptations to strength and power training. In P. V. Komi (Ed.), *Strength and power in sport* (2nd ed., pp. 361-386). Oxford [u.a.]: Blackwell Science.

Kraemer, W. J., & Ratamess, N. A. (2005). Hormonal responses and adaptations to resistance exercise and training. *Sports Medicine, 35*(4), 339-361.

Kraemer, W. J., Vingren, J. L., & Spiering, B. A. (2008). Endocrine responses to resistance exercise. In T. R. Baechle & R. W. Earle (Eds.), *Essentials of strength training and conditioning*. Champaign, IL: Human Kinetics.

© COPYRIGHT UPM

Kraemer, W. J., Volek, J. S., Bush, J. A., Putukian, M., & Sebastianelli, W. J. (1998). Hormonal responses to consecutive days of heavy-resistance exercise with or without nutritional supplementation. *Journal of Applied Physiology, 85*(4), 1544.

Kreider , R., Wilborn, C., Taylor, L., Campbell, B., Almada, A., Collins, R., et al. (2010). ISSN exercise & sport nutrition review: research & recommendations. *Journal of the international society of sports nutrition, 7*(1), 7.

Kreider, R. B., Fry, A. C., & O'Toole, M. L. (1998). *Overtraining in sport*. Champaign, IL: Human Kinetics.

Kreider, R. B., Leutholtz, B. C., Katch, F. I., & Katch, V. L. (2009). *Exercise & sport nutrition : principles, promises, science, & recommendations : the ultimate training and nutrition guide to optimal health, fitness, and performance*. Santa Barbara, CA: Fitness Technologies Press.

Kvorning, T., Andersen, M., Brixen, K., & Madsen, K. (2006). Suppression of endogenous testosterone production attenuates the response to strength training: a randomized, placebo-controlled, and blinded intervention study. *American Journal of Physiology, Endocrinology and Metabolism, 291*(6), E1325-1332.

LeMura, L. M., von Duvillard, S. P., Andreacci, J., Klebez, J. M., Chelland, S. A., & Russo, J. (2000). Lipid and lipoprotein profiles, cardiovascular fitness, body composition, and diet during and after resistance, aerobic and combination training in young women. *European Journal of Applied Physiology, 82*(5), 451-458.

Lichti, E., Turner, M., Deweese, M., & Henzel, J. (1970). Zinc concentration in venous plasma before and after exercise in dogs. *Mo Med*, 303-304.

Ling, W. H., & Jones, P. J. (1995). Mini-review of dietary phytosterols: a review of metabolism, benefits and side effects. *Life Sci, 57*, 195-206.

Lippi, G., Banfi, G., Franchini, M., & Guidi, G. C. (2008). New strategies for doping control. *Journal of sports sciences, 26*(5), 441-445.

Lukaski, H. C. (1995). Micronutrients (magnesium, zinc and copper): are mineral supplements needed for athletes? *International Journal of Sport Nutrition, 5 Suppl*, 74-83.

Lukaski , H. C. (2000). Magnesium, zinc, and chromium nutriture and physical activity. *American Journal of Clinical Nutrition, 72*(2), 585S-593.

Machin, D., Campbell, M. J., John, W., Sons, & Wiley, I. (2005). Design of studies for medical research.

© COPYRIGHT UPM

Maravelias, C., Dona, A., Stefanidou, M., & Spiliopoulou, C. (2005). Adverse effects of anabolic steroids in athletes: a constant threat. *Toxicology letters, 158*(3), 167-175.

Marques, L., Donangelo, C., Franco, J., Pires, L., Luna, A., Casimiro-Lopes, G., et al. (2010). Plasma Zinc, Copper, and Serum Thyroid Hormones and Insulin Levels After Zinc Supplementation Followed by Placebo in Competitive Athletes. *Biological Trace Element Research*, 1-9.

Marx, J. O., Ratamess, N. A., Nindl, B. C., Gotshalk, L. A., Volek, J. S., Dohi, K., et al. (2001). Low-volume circuit versus high-volume periodized resistance training in women. *Medical Science Sports Exercise, 33*, 635-643.

Matsuse, H., Nago, T., Takano, Y., & Shiba, N. (2010). Plasma Growth Hormone Is Elevated Immediately after Resistance Exercise with Electrical Stimulation and Voluntary Muscle Contraction. *The Tohoku Journal of Experimental Medicine, 222*(1), 69-75.

Maughan, R. J. (1999). Role of micronutrients in sport and physical activity. *British Medical Bulletin, 55*(3), 683-690.

McCall , G. E., Byrnes, W. C., Dickinson, A., Pattany, P. M., & Fleck, S. J. (1996). Muscle fiber hypertrophy, hyperplasia, and capillary density in college men after resistance training. *Journal of Applied Physiology, 81*(5), 2004.

McCall, G. E., Byrnes, W.C., Fleck, S.J., Dickinson, A., Kraemer, W.J. (1999). Acute and chronic hormonal responses to resistance training designed to promote muscle hypertrophy. *Canadian Journal of Applied Physiology, 24*, 96-107.

McCaulley, G., McBride, J., Cormie, P., Hudson, M., Nuzzo, J., Quindry, J., et al. (2009). Acute hormonal and neuromuscular responses to hypertrophy, strength and power type resistance exercise. *European Journal of Applied Physiology, 105*(5), 695-704.

McGuigan, M. R., Tatasciore, M., Newton, R. U., & Pettigrew, S. (2009). Eight Weeks of Resistance Training Can Significantly Alter Body Composition in Children Who Are Overweight or Obese. *The Journal of Strength & Conditioning Research, 23*(1), 80-85 10.1519/JSC.1510b1013e3181876a3181856.

McKoy, G., Ashley, W., Mander, J., Yang, S. Y., Williams, N., Russell, B., et al. (1999). Expression of insulin growth factor-1 splice variants and structural genes in rabbit skeletal muscle induced by stretch and stimulation. *The Journal of Physiology, 516*(2), 583-592.

McMurray, R. G., Eubank, T. K., & Hackney, A. C. (1995). Nocturnal hormonal responses to resistance exercise. *European Journal of Applied Physiology and Occupational Physiology, 72*(1), 121-126.

© COPYRIGHT UPM

McMurray, R. G., & Hackney, A. C. (2000). Endocrine responses to exercise and training. In W. E. Garrett (Ed.), *Exercise and sport science* (pp. 135-162). Philadelphia [u.a.]: Lippincott Williams & Wilkins.

Metin, G., Atukeren, P., Alturfan, A. A., Gülyaşar, T., Kaya, M., & Gümüştaş, M. K. (2003). Lipid Peroxidation, Erythrocyte Superoxide-Dismutase Activity and Trace Metals in Young Male Footballers. *Yonsei Med J, 44*(6), 979-986.

Michels, G., & Hoppe, U. C. (2008). Rapid actions of androgens. *Frontiers in Neuroendocrinology, 29*(2), 182-198.

Molinero, O., & Marquez, S. (2009). Use of nutritional supplements in sports: risks, knowledge, and behavioural-related factors. *Nutricin Hospitalaria, 24*, 128-134.

Moore, D. R., Robinson, M. J., Fry, J. L., Tang, J. E., Glover, E. I., Wilkinson, S. B., et al. (2009). Ingested protein dose response of muscle and albumin protein synthesis after resistance exercise in young men. *American Journal of Clinical Nutrition, 89*(1), 161-168.

Nindl, B. C., Alemany, J. A., Kellogg, M. D., Rood, J., Allison, S. A., Young, A. J., et al. (2007). Utility of circulating IGF-I as a biomarker for assessing body composition changes in men during periods of high physical activity superimposed upon energy and sleep restriction. *Journal of Applied Physiology, 103*(1), 340-346.

Nindl , B. C., Kraemer, W. J., Marx, J. O., Arciero, P. J., Dohi, K., Kellogg, M. D., et al. (2001). Overnight responses of the circulating IGF-I system after acute, heavy-resistance exercise. *Journal of Applied Physiology, 90*(4), 1319.

Norton, R. A. (1995). Quantitation of steryl ferulate and p-coumarate esters from corn and rice bran. *Lipids, 30*, 269-274.

Notelovitz, M. (1997). Estrogen Therapy and Osteoporosis: Principles & Practice. *The American Journal of the Medical Sciences, 313*(1), 2-12.

Nuviala, R. J., Lapieza, M. G., & Bernal, E. (1999). Magnesium, zinc, and copper status in women involved in different sports. *International Journal of Sport Nutrition, 9*(3), 295-309.

Orthoefer, F. T. (2005). *Rice Bran Oil*: John Wiley & Sons, Inc.

Pakarinen, A., Alén, M., Häkkinen, K., & Komi, P. (1988). Serum thyroid hormones, thyrotropin and thyroxine binding globulin during prolonged strength training. *European Journal of Applied Physiology and Occupational Physiology, 57*(4), 394-398.

Pakarinen , A., Häkkinen , K., & Alen , M. (1991). Serum thyroid hormones, thyrotropin and thyroxine binding globulin in elite athletes during very intense strength training of one week. *The Journal of Sports Medicine and Physical Fitness, 31*(2), 142-146.

© COPYRIGHT UPM

Palmer, M. E., Haller, C., McKinney, P. E., Klein-Scwartz, W., Tschirgi, A., & Smolinske, S. C., et al. (2003). Adverse events associatedwith dietary supplements: an observational study. *Lancet, 361*(101-106).

Park, D. H., & Ransone, J. W. (2003). Effects of Submaximal Exercise on High-Density Lipoprotein-Cholesterol Subfractions. *International Journal of Sports Medicine, 24*(04), 245,251.

Patel, M., & Naik, S. N. (2004). Gamma-oryzanol from rice bran oil- A review. *Journal of Scientific & Industrial Research, 63*, 569-578.

Perretti , G., Miniati , E., Montanari , L., & Fantozzi , P. (2003). Improving the value of rice by-products by SFE. *Journal of Supercritical Fluids, 26*(26), 63-71.

Plat , J., & Mensink , R. P. (2001). Effects of plant stanol esters on LDL receptor protein expression and on LDL receptor and HMG-CoA reductase mRNA expression in mononuclear blood cells of healthy men and women. *FASEB Journal*, 01-0653fje.

Plat, J., & Mensink, R. P. (2001). Effects of plant sterols and stanols on lipid metabolism and cardiovascular risk. *Nutrition, Metabolism & Cardiovascular Diseases, 11*, 31-40.

Plat, J., Van Onselen, E. N., Van Heugten, M. M., & Mensink, R. P. (2000). Effects on serum lipids, lipoproteins and fat soluble antioxidant concentrations of consumption frequency of margarines and shortenings enriched with plant stanol esters. *European Journal of Clinical Nutrition, 54*, 671-677.

Pohl, A. P., O'Halloran, M. W., & Pannall, P. R. (1981). Biochemical and physiological changes in football players. *The Medical Journal of Australia, 2*(19), 467-470.

Potricia, A. D., & Rita, G. S. (2004). *Dietary supplementaion and military divers: a synopsis for undersea medical officers* (1st edition ed.). New York: Uniformed Services University of the Health Sciences.

Prabhakaran, B., Dowling, E. A., Branch, J. D., Swain, D. P., & Leutholtz, B. C. (1999). Effect of 14 weeks of resistance training on lipid profile and body fat percentage in premenopausal women. *British Journal of Sports Medicine, 33*(3), 190-195.

Raastad, T., Bjoro, T., & Hallén, J. (2000). Hormonal responses to high- and moderate-intensity strength exercise. *European Journal of Applied Physiology, 82*(1), 121-128.

Raastad , T., Glomsheller, T., Bjoro, T., & Hallén, J. (2001). Changes in human skeletal muscle contractility and hormone status during 2 weeks of heavy strength training. *European Journal of Applied Physiology, 84*(1), 54-63.

Raastad , T., Glomsheller, T., Bjoro, T., & Hallén, J. (2003). Recovery of skeletal muscle contractility and hormonal responses to strength exercise after two

© COPYRIGHT UPM

weeks of high volume strength training. *Scandinavian Journal of Medicine & Science in Sports, 13*(3), 159-168.

Raghuram, T. C., & Brahmaji, R. (1989). Studies on hypolipidemic effects of dietary rice bran oil in human subjects. *Nutrition reports international, 39*(5), 889-895.

Ratamess , N. A., Kraemer, W. J., Volek, J. S., Maresh, C. M., Van Heest, J. L., Rubin, M. R., et al. (2004). Effects of Heavy Resistance Exercise Volume on Post-Exercise Androgen Receptor Content in Resistance-Trained Men. *Medicine & Science in Sports & Exercise, 36*(5), S238.

Resina, A., Fedi, S., Gatteschi, L., Rubenni, M. G., Giamberardino, M. A., Trabassi, E., et al. (1990). Comparison of Some Serum Copper Parameters in Trained Runners and Control Subjects. *International Journal of Sports Medicine, 11*(01), 58,60.

Resina, A., Gatteschi, L., Rubenni, M. G., Giamberardino, M. A., & Imreh, F. (1991). Comparison of some serum copper parameters in trained professional soccer players and control subjects. *The Journal of Sports Medicine and Physical Fitness, 31*(3), 413-416.

Ritchie, M. R. (2007). Use of herbal supplements and nutritonal supplements in the UK: Whatdo we know about their patterns of usage? . *Proceedings of the Nutrition Society, 66*, 479-482.

Rodriguez Tuya, I., Pinilla Gil, E., Maynar Mariño, M., García-Moncó Carra, R., & Sánchez Misiego, A. (1996). Evaluation of the influence of physical activity on the plasma concentrations of several trace metals. *European Journal of Applied Physiology and Occupational Physiology, 73*(3), 299-303.

Rogers , E., Rice , S., Nicolosi , R., Carpenter , D., McClelland , C., & Romanczyk , L. (1993). Identification and quantization of γ-oryzanol components and simultaneous assessment of tocols in rice bran oil. *Journal of the American Oil Chemists' Society, 70*(4), 301-307.

Rong , N., Ausman , L. M., & Nicolosi , R. J. (1997). Oryzanol decreases cholesterol absorption and aortic fatty streaks in hamsters. *Lipids, 32*, 303-309.

Rosner, W. (1990). the functions of corticosteroid-binding globulin and sex hormone-binding globulin: Recent advances. *Endocrine Reviews, 11*, 80-91.

Rubin, M. R., Kraemer, W. J., Maresh, C. M., Volek, J. S., Ratamess, N. A., Vanheest, J. L., et al. (2005). High-affinity growth hormone binding protein and acute heavy resistance exercise. *Medicine & Science in Sports & Exercise, 37*(3), 395.

Sakamoto , K., Tabata , T., Shirasaki , K., Inagaki , T., & Nakayama , S. (1987). Effects of gamma-oryzanol and cycloartenol ferulicacid ester on cholesterol diet induced hyperlipidemia in rats. *Japanese Journal of Pharmacology, 45*, 559-565.

© COPYRIGHT UPM

Sallinen, J., Fogelholm, M., Volek, J. S., Kraemer, W. J., Alen, M., & Hĺ¤kkinen, K. (2007). Effects of Strength Training and Reduced Training on Functional Performance and Metabolic Health Indicators in Middle-Aged Men. *International Journal of Sports Medicine, 28*(10), 815,822.

Sanavi, S., Kohanpour, M.-A., & Kohanpour, M. (2012). Effects of intermittent and continuous resistance training on proteinuria and hematuria in trained young women. *Clinical Kidney Journal*.

Sasaki , J., Takada , Y., & Handa , K., et al. (1990). Effects of gamma-oryzanol on serum lipid and apolipoproteins in dyslipidemic schizophrenics receiving major tranquilizers. *Clinical Therapeutics, 12*, 263-268.

Scavariello, E., & Arellano, D. (1998). Gamma-oryzanol: an important component in rice brain oil. *Archivos latinoamericanos de nutricin, 48*(1), 7.

Schoenfeld, B. J. (2010). The Mechanisms of Muscle Hypertrophy and Their Application to Resistance Training. *Journal of Strength and Conditioning Research, 24*(10), 2857-2872.

Schramm, R., Abadie, A., Hua, N., Xu, Z., & Lima, M. (2007). Fractionation of the rice bran layer and quantification of vitamin E, oryzanol, protein, and rice bran saccharide. *Journal of Biological Engineering, 1*(9), 1-9.

Seetharamaiah , G. S., & Chandrasekhara , N. (1988). Studies on hypocholesterolemic activity of oryzanol in rats. *Nutrition Report International, 38*, 927-932.

Seetharamaiah, G. S., & Chandrasekhara, N. (1989). Studies on Hypocholesterolemic Activity of Rice Bran Oil. *Atherosclerosis, 78*, 219-223s.

Senchina, D. S., Shah, N. B., Doty, D. M., Sanderson, C. R., & Hallam, J. E. (2009). Herbal Supplements and Athlete Immune Function –What's Proven, Disproven, and Unproven? *Exercise Immunology Review, 15*, 66-106.

Sengupta , S., Toh , S., Sellers , L., & et al. (2004). Modulating angiogenesis: The yin and yang in ginseng. *Circulation, 110*, 1219-1225.

Sheffield-Moore, M., Paddon-Jones, D., Sanford, A. P., Rosenblatt, J. I., Matlock, A. G., Cree, M. G., et al. (2005). Mixed muscle and hepatic derived plasma protein metabolism is differentially regulated in older and younger men following resistance exercise. *American Journal of Physiology, Endocrinology and Metabolism, 288*(5), E922-929.

Shephard, R. J., & Shek, P. N. (1998). Immunological hazards from nutritional imbalance in athletes. *Exercise Immunology Review, 4*, 22-48.

Shinomiya, M. M., N. Matsuoka, N. Izumi, S. Saito, Y. Kumagai, A. Mitani, K. Morita, S. (1983). Effects of γ-Oryzanol on Lipid Metabolism in Rats Fed

© COPYRIGHT UPM

High-Cholesterol Diet. *The Tohoku Journal of Experimental Medicine, 141*, 191-197.

Silver, M. D. (2001). Use of ergogenic aids by athletes. *Journal of the American Academy of Orthopaedic Surgeons, 9*, 61-70.

Simsch, C., Lormes, W., Petersen, K. G., Baur, S., Liu, Y., Hackney, A. C., et al. (2002). Training Intensity Influences Leptin and Thyroid Hormones in Highly Trained Rowers. *International Journal of Sports Medicine, 23*(06), 422,427.

Siri, W. (1956). The gross composition of the body. *Advances in biological and medical physics, 4*, 239.

Smilios, I., Pilianidis, T., Karamouzis, M., & Tokmakidis, S. p. (2003). Hormonal Responses after Various Resistance Exercise Protocols. *Medicine & Science in Sports & Exercise, 35*(4), 644-654.

Smith, D., & Perry, P. (1992). Part I: Androgenic-anabolic steroids *The efficacy of ergogenic agents in athletic competition* (Vol. 26, pp. 520-528): The Annals of Pharmacotherapy.

Sobal, J., & Marquart, L. F. (1994). Vitamin/mineral supplement use among athletes: a review of the literature. *International Journal of Sport Nutrition, 4*(4), 320-334.

Sonksen, P. (2001). Insulin, growth hormone and sport. *Journal of Endocrinology, 170*(1), 13-25.

Speich, M., Pineau, A., Ballereau, F. (2001). Minerals, trace elements and related biological variables in athletes and during physical activity. *Clinica Chimica Acta, 312*, 1-11.

Spiering, B. A., Kraemer, W. J., Anderson, J. M., Armstrong, L. E., Nindl, B. C., Volek, J. S., et al. (2008). Resistance Exercise Biology: Manipulation of Resistance Exercise Programme Variables Determines the Responses of Cellular and Molecular Signalling Pathways. *Sports Medicine, 38*, 527-540.

Staron, R. S., Karapondo, D. L., Kraemer, W. J., Fry , A. C., Grordon, S. E., Falkel, J. E., et al. (1994). Skeletal muscle adaptations during the early phase of heavy-resistance training in men and women. *Journal of Applied Physiology, 76*(3), 1247-1255.

Stevens-Simon , C., Thureen, P., Barrett, J., & Stamm, E. (2001). Skinfold caliper and ultrasound assessments of change in the distribution of subcutaneous fat during adolescent pregnancy. *International Journal of Obesity, 25*, 1340-1345.

Stokes , K., Nevill, M., Frystyk, J., Lakomy, H., & Hall, G. (2005). Human growth hormone responses to repeated bouts of sprint exercise with different recovery periods between bouts. *J Appl Physiol, 99*(4), 1254-1261.

© COPYRIGHT UPM

Stokes, K. A., Sykes, D., Gilbert, K. L., Chen, J.-W., & Frystyk, J. (2010). Brief, high intensity exercise alters serum ghrelin and growth hormone concentrations but not IGF-I, IGF-II or IGF-I bioactivity. *Growth Hormone & IGF Research, 20*(4), 289-294.

Stone, M. H., Fleck, S.J., Triplett, N.T., Kraemer, W.J. (1991). Health- and performance-related potential of resistance training. *Sports Medicine 11*, 210-231.

Subbiah, M. T. R. (1973). Dietary plant sterols: current status in human and animal sterol metabolism. *American Journal of Clinical Nutrition, 26*(2), 219-225.

Takemoto, T., Miyoshi, H., & Nagashima, H. (1977). Clinical trial of Hi-Z fine granules (gamma-oryzanol) on gastrointestinal symptoms at 375 hospitals (Japan). *Shinyaku To Rinsho, 26*.

Talbott, S. M. (2003). *A Guide to Understanding Dietary Supplements*: Routledge.

Tausha, R. (2000). Dietary supplements and strength-trained athletes. In G. Catherine & J. Ratzin (Eds.), *Nutrition and strength athlete* (1st ed., pp. 120-123). Washington, D.C: CRC Press.

Tekin, K. A., & Kravitz, L. (2004). The growing trend of ergogenic drugsand supplements. *ACSM'S Health Fitness J, 8*, 15-18.

Thieme, D., Hemmersbach, P., Thevis, M., Thomas, A., & Schänzer, W. (2010). Insulin *Doping in Sports: Biochemical Principles, Effects and Analysis* (Vol. 195, pp. 209-226): Springer Berlin Heidelberg.

Thyfault , J. P., Carper, M. J., Richmond, S. R., Hulver, M. W., & Potteiger, J. A. (2004). Effects of Liquid Carbohydrate Ingestion on Markers of Anabolism Following High-Intensity Resistance Exercise. *The Journal of Strength & Conditioning Research, 18*(1), 174-179.

Tikkanen, H. O., Hämäläinen, E., & Härkönen, M. (1999). Significance of skeletal muscle properties on fitness, long-term physical training and serum lipids. *Atherosclerosis, 142*(2), 367-378.

Tikkanen, H. O., Hämäläinen, E., Sarna, S., Adlercreutz, H., & Härkönen, M. (1998). Associations between skeletal muscle properties, physical fitness, physical activity and coronary heart disease risk factors in men. *Atherosclerosis, 137*(2), 377-389.

Tissandier, Péres, Fiet, & Piette. (2001). Testosterone, dehydroepiandrosterone, insulin-like growth factor 1, and insulin in sedentary and physically trained aged men. *European Journal of Applied Physiology, 85*(1), 177-184.

Toigo, M., & Boutellier, U. (2006). New fundamental resistance exercise determinants of molecular and cellular muscle adaptations. *European Journal of Applied Physiology, 97*(6), 643-663.

© COPYRIGHT UPM

Tremblay, M. S., Copeland, J. L., & Van Helder, W. (2003). Effect of training status and exercise mode on endogenous steroid hormones in men. *Journal of Applied Physiology, 96*(2), 531-539.

Tsai, Y., Chou, S., Lin, Y., Hou, C., Hung, K., Kung, H., et al. (2006). Effect of resistance exercise on dehydroepiandrosterone sulfate concentrations during a 72-h recovery: Relation to glucose tolerance and insulin response. *Life sciences, 79*(13), 1281-1286.

Vanhelder, W., Radomski, M., & Goode, R. (1984). Growth hormone responses during intermittent weight lifting exercise in men. *European Journal of Applied Physiology and Occupational Physiology, 53*(1), 31-34.

Vierck, J., O'Reilly, B., Hossner, K., Antonio, J., Byrne, K., Bucci, L., et al. (2000). Satellite cell regulation following myotrauma caused by resistance exercise. *Cell Biology International, 24*(5), 263-272.

Villareal, D. T., & Holloszy, J. O. (2004). Effect of DHEA on Abdominal Fat and Insulin Action in Elderly Women and Men: A Randomized Controlled Trial. *Journal of the American Medical Association, 292*(18), 2243-2248.

Villareal, D. T., & Holloszy, J. O. (2006). DHEA enhances effects of weight training on muscle mass and strength in elderly women and men. *American Journal of Physiology, Endocrinology and Metabolism, 291*(5), E1003-1008.

Vingren, J. L., Kraemer, W. J., Hatfield, D. L., Volek, J. S., Ratamess, N. A., Anderson, J. M., et al. (2009). Effect of resistance exercise on muscle steroid receptor protein content in strength-trained men and women. *Steroids, 74*(13-14), 1033-1039.

Viru, A., & Viru, M. (2001). *Biochemical monitoring of sport training*. Champaign, Ill. [u.a.]: Human Kinetics.

Visser, M., Kritchevsky, S.B., Newman, A.B., Goodpaster, B.H., Tylavsky, F.A., Nevitt, M.C., Harris, T.B. (2005). Lower serum albumin concentration and change in muscle mass: the Health, Aging and Body Composition Study. *American Journal of Clinical Nutrition, 82*, 531-537.

Volek, J., Ratamess, N., Rubin, M., Gómez, A., French, D., McGuigan, M., et al. (2004). The effects of creatine supplementation on muscular performance and body composition responses to short-term resistance training overreaching. *European Journal of Applied Physiology, 91*(5), 628-637.

WADA. (2010). The 2010 Prohibited List. from http://www.wada-ama.org/Documents/World_Anti-Doping_Program/WADP-Prohibited-list/WADA_Prohibited_List_2010_EN.pdf

West, D. W. D., Burd, N. A., Tang, J. E., Moore, D. R., Staples, A. W., Holwerda, A. M., et al. (2010). Elevations in ostensibly anabolic hormones with resistance exercise enhance neither training-induced muscle hypertrophy nor strength of the elbow flexors. *Journal of Applied Physiology, 108*(1), 60-67.

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Wheeler , K. B., & Garleb, K. A. (1991). Gamma oryzanol-plant sterol supplementation: metabolic, endocrine, and physiologic effects. *International Journal of Sport Nutrition, 1*, 170-177.

Wideman, L., Weltman, J. Y., Hartman, M. L., Veldhuis, J. D., & Weltman, A. (2002). Growth Hormone Release During Acute and Chronic Aerobic and Resistance Exercise: Recent Findings. *Sports Medicine, 32,* 987-1004.

Wiik, A., Glenmark, B., Ekman, M., Esbjörnsson Liljedahl, M., Johansson, O., Bodin, K., et al. (2003). Oestrogen receptor is expressed in adult human skeletal muscle both at the mRNA and protein level. *Acta Physiologica Scandinavica, 179*(4), 381-387.

Wilkinson, S., Tarnopolsky, M., Grant, E., Correia, C., & Phillips, S. (2006). Hypertrophy with unilateral resistance exercise occurs without increases in endogenous anabolic hormone concentration. *European Journal of Applied Physiology, 98*(6), 546-555.

Williams, M. (2005). *Nutrition for health, fitness & sports*. New York: McGraw-Hill.

Williams , M. A., Haskell, W., Ades, P., Amsterdam, E., Bittner, V., Franklin, B., et al. (2007). Resistance exercise in individuals with and without cardiovascular disease: 2007 update: a scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism. *Circulation, 116*(5), 572.

Williams, M. H. (2006). Dietary supplements and sport performance: herbals. *Journal of the international society of sports nutrition, 3*(1), 1-6.

Wilmore, J. H., Costill, D. L., & Kenney, W. L. (2008). *Physiology of sport and exercise*. Champaign, IL: Human Kinetics.

Wilson, T. A., Nicolosi, R. J., Woolfrey, B., & Kritchevsky, D. (2007). Rice bran oil and oryzanol reduce plasma lipid and lipoprotein cholesterol concentrations and aortic cholesterol ester accumulation to a greater extent than ferulic acid in hypercholesterolemic hamsters. *The Journal of Nutritional Biochemistry, 18*(2), 105-112.

Winterstein, A., & Storrs, C. (2001). Herbal supplements: considerations for the athletictrainer. *Journal of Athletic Training, 36,* 425-432.

Wolfe, R. R. (2000). Effects of insulin on muscle tissue. *Current Opinion in Clinical Nutrition & Metabolic Care, 3*(1), 67-71.

Xu, Z., & Godber, J. S. (1999). Purification and identification of components of γ– oryzanol in rice bran oil. *Journal of Agriculture Food Chemistry, 47,* 2724-2728.

Xu , Z., Hua, N., & Godber, J. S. (2001). Antioxidant activity of tocopherols, tocotrienols, and gamma oryzanol components from rice bran against cholesterol oxidation accelerated by 2,21-azobin(2 methylpropionamideine)

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dihydrochloride. *Journal of Agricultural and Food Chemistry, 49*(4), 2077-2081.

Yang, S., Chen, C., Liao, Y., Lin, F., Lee, W., Cho, Y., et al. (2005). Interactive effect of an acute bout of resistance exercise and dehydroepiandrosterone administration on glucose tolerance and serum lipids in middle-aged women. *Chinese Journal of Physiology, 48*(1), 23.

Yoshino, G., Kazumi, T., Amano, M., Takeiwa, M., Yamasaki, T., Takashima, S., Iwai, M., Hatanaka, H., Baba, S. (1989). Effects of gamma-oryzanol and probucol on hyperlipidemia. *Current Therapy Research, 45*, 975-982.

Zatsiorsky, V. M., & Kraemer, W. J. (2006). *Science and practice of strength training* (second ed.). Champaign, IL: Human Kinetics

Ziegler, W. H., Nelson, J. A., & Jonnalagadda, S. S. (2003). Use of dietary supplements by elitefigure skaters. . *International Journal of Sport Nutrition and Exercise Metabolism, 13*, 266-276.

Zuliani, G., Romagnoni, F., Volpato, S., Soattin, L., Leoci, V., Bollini, M. C., et al. (2001). Nutritional Parameters, Body Composition, and Progression of Disability in Older Disabled Residents Living in Nursing Homes. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56*(4), M212-M216.

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