DIETARY SUPPLEMENTATION & RESISTANCE TRAINING PROGRAMS DESIGNED TO PROMOTE INCREASES IN MUSCLE MASS

By Paul J Cribb  B H Sci (HMS); B Chem Sci (Hons); CSCS
PhD Candidate ID: 3095920

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Supervisor: Dr Alan Hayes
School of Biomedical Sciences
Victoria University
PO Box 14428 MCMC
Melbourne Vic 8001 Australia
Declaration

I, Paul John Cribb, declare that the PhD thesis entitled *Dietary Supplementation & Resistance Training Programs Designed to Promote Increases in Muscle Mass* is no more than 100,000 words in length, exclusive of tables, figures, appendices, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

July 28th 2006
### Abstract

Abstract

### Preface

Preface

### Acknowledgements

Acknowledgements

### List of figures

List of figures

### List of tables

List of tables

### Abbreviations

Abbreviations

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#### Chapter 1: Introduction

1.1 Populations that would benefit from this research

1.2 Factors that regulate the size of human skeletal muscle mass

1.3 Resistance exercise: Adaptations and influences that may affect muscle hypertrophy

1.4 Resistance exercise, protein turnover and muscle hypertrophy

1.5 The molecular events associated with muscle hypertrophy

1.6 Acute responses to nutrient intake & resistance exercise associated with hypertrophy

1.7 Chronic responses to nutrient intake & resistance exercise associated with hypertrophy

1.8 The potential of whey protein to enhance muscle hypertrophy

1.9 The potential of creatine monohydrate to enhance muscle hypertrophy

1.10 Resistance exercise program design for muscle hypertrophy

1.11 Summary

---

#### Chapter 2: Methods & Procedures

2.1 Participants

2.2 Supplementation

2.3 Dietary recordings

2.4 Resistance training protocol

2.5 Strength assessments

2.6 Body composition assessment

2.7 Muscle sampling, treatment and analyses

2.8 Statistics
Abstract

Lifestyle strategies that focus on building/preserving skeletal muscle mass will enhance the health of a wide sector of the population and possibly, diminish the severity of many ageing-related illnesses. The focus of this dissertation was to examine the effects of strategic intervention with dietary supplements and exercise designed specifically to promote an increase in muscle mass (hypertrophy). Three separate trials were completed using healthy adult males (aged 18-36 years). Each trial utilized a randomized, double-blinded design that involved 10-11 weeks of structured RE training and matched groups that supplemented their diets with whey protein (WP), creatine monohydrate (CrM) and/or carbohydrate (CHO) (separately and in various combinations as well as at strategic times of the day). Assessments included body composition (lean mass, fat mass and body fat %), maximum (absolute) strength in three weight lifting exercises, and vastus lateralis muscle biopsies for determination of muscle fibre types (I, IIA and IIX), cross-sectional area (CSA), energy metabolite and glycogen concentrations as well as contractile protein content. The results of study-1 (chapter-3), demonstrated that despite the consumption of a high protein intake by all groups and no differences between the groups before the study, supplementation with CrM and/or WP resulted in greater \( P < 0.05 \) improvements in strength (in three assessments) compared to supplementation with an equivalent dose of CHO. These improvements correlated strongly \( r \geq 0.7; P < 0.01 \) with the differences \( P < 0.05 \) in skeletal muscle morphology that were detected among the groups. The results from study-2 (chapter-4) demonstrated that a CrM-containing WP-CHO supplement provided a significantly greater improvement in body composition (increase in lean mass and decrease in body fat %; \( P < 0.05 \)), greater gains in strength and muscle hypertrophy (type-IIA and IIX muscle fibre CSA and contractile protein content; \( P < 0.05 \)) compared to a group given the same supplement without CrM. In study-3 (chapter 5) the effects of supplement-timing (i.e., the strategic consumption of a WP-CrM supplement immediately before and after exercise) was compared to the consumption of the same supplement at times outside of the pre- and post-workout period. Supplement-timing resulted in a better improvement in body composition \( P < 0.05 \), greater gains in strength (in 2 out of the 3 assessments) \( P < 0.05 \) and muscle hypertrophy \( P < 0.05 \). Very few studies involving exercise training and supplementation have reported favourable changes in body composition alongside alterations at the cellular (fibre type specific hypertrophy) and subcellular (contractile protein content) levels. The research provides data on non-pharmaceutical, cost-effective strategies that could be easily implemented by a wide sector of the population to build/maintain muscle mass throughout the lifespan, and therefore, reduce the severity of many ageing-related illnesses as well as the economic burden on the health care system.
Preface

The research within this dissertation has undergone peer-review and has been presented at the following academic gatherings:

- Experimental Biology Meeting, 2003 (featured presentation by the American Physiological Society)
- The Australian Association for Exercise and Sports Science’s Annual Meeting, 2004 (Awarded Young Investigator of the Year).
- The American College of Sports Medicine’s Annual Meeting, 2002, 2003, 2005 (selected for oral presentation each year)
- The Australian Academy of Technological Sciences and Engineering’s Annual Meeting 2004 (awarded an Early Career Research Fellowship).

published in the following journals

- Medicine and Science in Sports and Exercise, 2006

and monographs

- Dairy Management Inc. (USA), 2004, 2006
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(like the Master Card commercial says... *priceless!* ) AST provided completely unconditional support throughout my studies, for which I will always be grateful.

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Finally, thank you to my reviewers for your precious time. Each of you has already had a profound influence in my development; the standard of your research is what I aspire to in the years ahead. Additionally, for my American reviewers, all spelling is in Australian/English format.

I think that’s everyone, so......... game on!
List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Regulators that affect protein turnover</td>
<td>5</td>
</tr>
<tr>
<td>1.2</td>
<td>Urea biosynthesis and the influence of the amino acid cysteine</td>
<td>7</td>
</tr>
<tr>
<td>1.3</td>
<td>Regulatory circuit of whole body protein metabolism (featuring cysteine)</td>
<td>8</td>
</tr>
<tr>
<td>1.4</td>
<td>The main functions of the Cr-PCr system in a muscle fibre</td>
<td>20</td>
</tr>
<tr>
<td>1.5</td>
<td>The reversible phosphorylation of Cr by ATP to form PCr and ADP</td>
<td>22</td>
</tr>
<tr>
<td>1.6</td>
<td>Signalling pathways that lead to muscle protein synthesis</td>
<td>33</td>
</tr>
<tr>
<td>1.7</td>
<td>Regulatory effects of cell volume</td>
<td>37</td>
</tr>
<tr>
<td>1.8</td>
<td>The Cr-Pi shuttle and its potential role in contractile-specific protein synthesis</td>
<td>62</td>
</tr>
<tr>
<td>2.1</td>
<td>Muscle fibre identification via myosin ATPase staining, pH 4.54 and 4.3</td>
<td>82</td>
</tr>
<tr>
<td>3.1</td>
<td>Changes in strength (1RM)</td>
<td>90</td>
</tr>
<tr>
<td>3.2</td>
<td>Changes in muscle fibre CSA</td>
<td>92</td>
</tr>
<tr>
<td>3.3</td>
<td>Changes in contractile protein content</td>
<td>93</td>
</tr>
<tr>
<td>3.4</td>
<td>Relationship between change in muscle fibre CSA and 1RM strength changes in the squat</td>
<td>95</td>
</tr>
<tr>
<td>3.5</td>
<td>Relationship between change in contractile protein content and 1RM strength changes in the squat</td>
<td>96</td>
</tr>
<tr>
<td>3.6</td>
<td>Relationship between change in contractile protein content and muscle fibre hypertrophy</td>
<td>97</td>
</tr>
<tr>
<td>4.1</td>
<td>Body composition changes</td>
<td>109</td>
</tr>
<tr>
<td>4.2</td>
<td>Changes in strength (1RM)</td>
<td>111</td>
</tr>
<tr>
<td>4.3</td>
<td>Changes in muscle fibre CSA</td>
<td>113</td>
</tr>
<tr>
<td>4.4</td>
<td>Changes in contractile protein content</td>
<td>114</td>
</tr>
<tr>
<td>4.5</td>
<td>Relationship between changes in muscle fibre CSA and 1RM strength changes in the squat</td>
<td>116</td>
</tr>
<tr>
<td>4.6</td>
<td>Relationship between change in contractile protein content and 1RM strength changes in the squat</td>
<td>117</td>
</tr>
<tr>
<td>4.7</td>
<td>Relationship between change in LBM and 1RM strength changes in the squat</td>
<td>118</td>
</tr>
<tr>
<td>5.1</td>
<td>Training day diet and supplementation schedules of the groups</td>
<td>128</td>
</tr>
<tr>
<td>5.2</td>
<td>Body composition changes</td>
<td>131</td>
</tr>
<tr>
<td>5.3</td>
<td>Changes in strength (1RM)</td>
<td>133</td>
</tr>
<tr>
<td>5.4</td>
<td>Changes in muscle fibre CSA</td>
<td>135</td>
</tr>
<tr>
<td>5.5</td>
<td>Changes in contractile protein content</td>
<td>136</td>
</tr>
</tbody>
</table>
5.6 Relationship between change in muscle fibre CSA and 1RM strength changes in the squat ................................................................. 138
5.7 Relationship between change in LBM and 1RM strength changes in the squat .................. 139
5.8 Relationship between change in contractile protein content and muscle fibre hypertrophy ........................................................................ 140

List of Tables

2.1 An example of the resistance training program used .................................................. 79
3.1 Baseline Characteristics ............................................................................................. 86
3.2 Dietary analyses ......................................................................................................... 87
3.3 Body mass and composition ...................................................................................... 88
3.4 Strength (1RM) ........................................................................................................ 89
3.5 Muscle fibre type (%) ............................................................................................... 91
3.6 Muscle fibre CSA and contractile protein ................................................................. 92
3.7 Muscle Metabolites .................................................................................................. 94
4.1 Baseline Characteristics ............................................................................................. 106
4.2 Dietary analyses ......................................................................................................... 107
4.3 Body mass and composition ...................................................................................... 108
4.4 Strength (1RM) ........................................................................................................ 110
4.5 Muscle fibre type (%) ............................................................................................... 112
4.6 Muscle fibre CSA and contractile protein ................................................................. 112
4.7 Muscle Metabolites .................................................................................................. 115
5.1 Baseline Characteristics ............................................................................................. 127
5.2 Dietary analyses ......................................................................................................... 129
5.3 Body mass and composition ...................................................................................... 130
5.4 Strength (1RM) ........................................................................................................ 132
5.5 Muscle fibre type (%) ............................................................................................... 134
5.6 Muscle fibre CSA and contractile protein ................................................................. 134
5.7 Muscle Metabolites .................................................................................................. 137
Abbreviations

AA, amino acids
ACTH, adrenocorticotropicin
ACSM, American College of Sports Medicine
ADP, adenosine diphosphate
AHA, American Heart Association
ANT, adenine nucleotide translocase
AMP, adenosine monophosphate
AMPK, AMP-dependent protein kinase
ATP, adenosine triphosphate
BMR, basal metabolic rate
BCAA, branch chain amino acids
CHO, carbohydrate
Cr, creatine
CrM, creatine monohydrate
CK, creatine kinase
CPK, creatine-phosphokinase
CSA, cross-sectional area
Cys, cysteine
DEXA, dual energy X-ray absorptiometry
DNA, deoxyribonucleic acid
EAA, essential amino acids
eIF-2, eukaryotic translation initiation factor2
eIF4E, eukaryotic translation initiation factor 4E
eIF4G, eukaryotic translation initiation factor 4G
4E-BP1, initiation factor 4E-binding protein 1
EMG, electromyographic
ERK1/2, ex-cellular signal-regulated kinase 1/2
FAK, focal adhesion kinase
FLRG, follistatin-like related gene
GH, growth hormone
GDF-8, growth differentiation factor 8
Glu, glutamate
Gln, glutamine
GSK3, glycogen synthase kinase 3
GSH, glutathione
HPA, hypothalamic-pituitary-adrenal axis
IGF-1, insulin-like growth factor 1
IGFBP, insulin-like growth factor binding proteins
IL-1, 1β, 1ra, 6,8,10; interleukin cytokines
LBM, lean body mass
MAPK, mitogen-activated protein kinase(s)
mATPase, myosin ATPase
MEF-2, myocyte enhancer factor 2
MHC, myosin heavy chain
MGF, mechano-growth factor
MPS, muscle protein synthesis
MPB, muscle protein breakdown
MRF, myogenic regulatory factors
mRNA, messenger ribonucleic acid
mTOR, mammalian target of rapamycin
MyoD, myoblast determination factor
NFAT, nuclear factor of activated T-cells
NPB, net protein balance
NSCA, National Strength & Conditioning Association
Pi, phosphate
PCr, phosphocreatine
p38, p38 stress-activated protein kinase
p70 S6k, p70 S6 (ribosomal protein) kinase
PI3K, phosphatidylinositol 30-kinase
PKB/Akt, protein kinase B
PRO, protein
PRO-CHO, protein-carbohydrate
RDA, Recommended daily allowance
RE, (conventional) resistance exercise
RM, repetition maximum
SR, sarcoplasmic reticulum
SREI, serum response element 1
SRF, serum response factor
TGF-β, transforming growth factor-β
TNF-α, tumour necrosis factor-alpha
WP, whey protein