

Avhandlingsserie för  
Gymnastik- och Idrottshögskolan

Nr 999

DETERMINANTS OF INTRA-INDIVIDUAL VARIATION IN  
ADAPTABILITY TO RESISTANCE TRAINING OF DIFFERENT  
VOLUMES WITH SPECIAL REFERENCE TO SKELETAL MUSCLE  
PHENOTYPES



Determinants of intra-individual  
variation in adaptability to resis-  
tance training of different volumes  
with special reference to skeletal  
muscle phenotypes

Daniel Hammarström

©Daniel Hammarström, Stockholm 2019

ISBN Provided by the library

Printed by Printer service, Stockholm, 2019

Distributor: Gymnastik- och idrottshögskolan

You can have a dedication here if you wish.

## THESIS FOR DOCTORAL DEGREE (Ph.D.)

### **The title of your thesis**

by

**Your name**

Thesis for Philosophy of Doctoral Degree in Sport Sciences, at The Swedish School of Sport and Health Sciences (GIH), which, according to the decision of the dean, will be publicly defended on *DATE*. The thesis defense will be held at the auditorium at The Swedish School of Sport and Health Sciences (GIH), Stockholm.

### **Opponent**

Profesor . . . .

### **Principal supervisor**

Profesor . . .

### **Co-supervisor(s)**

-Professor . . .

-Professor . . .

-Professor . . .

### **Examination board**

-Associate professor . . .

-Professor . . .

-Professor . . .

# Abstract

The preface pretty much says it all.

Second paragraph of abstract starts here.





# List of scientific papers

- I. **Hammarström D**, Øfsteng S, Koll L, Hanestadhaugen M, Hollan I, Apró W, Blomstrand E, Rønnestad B, Ellefsen S Benefits of higher resistance-training volume are related to ribosome biogenesis. *The Journal of physiology*. 2020;598(3):543-65.
- II. Khan Y, **Hammarström D**, Rønnestad B, Ellefsen S, Ahmad R Increased biological relevance of transcriptome analyses in human skeletal muscle using a model-specific pipeline. *Submitted*.
- III. **Hammarström D**, Øfsteng S, Jacobsen N, Flobergseter K, Rønnestad B, Ellefsen S Ribosome accumulation during early phase resistance training. *Manuscript*



# Contents

<b>List of Tables</b> . . . . .	<b>xiii</b>
<b>List of Figures</b> . . . . .	<b>xv</b>
<b>1 thesisdown::thesis_gitbook: default</b> . . . . .	<b>1</b>
<b>2 Background</b> . . . . .	<b>3</b>
2.1 Effects of resistance exercise volume on muscle strength and mass .	3
2.2 Ribosomal biogenesis . . . . .	3
2.3 Effects of resistance training and resistance training volume on muscle molecular characteristics . . . . .	3
2.4 The relationship between muscle mass and strength . . . . .	3
2.5 Molecular determinants of training-induced muscle hypertrophy . .	3
2.5.1 Protein synthesis . . . . .	3
2.5.2 The mammalian target of rapamycin (mTOR) and transla- tional efficiency . . . . .	3
2.6 Ribosome biogenesisand muscle growth . . . . .	3
<b>3 Aims</b> . . . . .	<b>5</b>
<b>4 Methods</b> . . . . .	<b>7</b>
4.1 Study participants, protocols and training interventions . . . . .	7
4.2 Resistance training interventions . . . . .	7
4.2.1 Ethical considerations . . . . .	7
4.3 Muscle strength assessments . . . . .	7
4.4 Muscle tissue sampling and preparations for downstream analyses .	7
4.5 Gene expression analysis . . . . .	7
4.6 Determination of protein abundance . . . . .	7
4.7 Statistics and data analysis . . . . .	7

---

4.8	Gene expression analysis . . . . .	7
4.8.1	Normalization . . . . .	7
<b>5</b>	<b>Results and Discussion . . . . .</b>	<b>9</b>
5.1	Effects of different training volume on changes in muscle size and function . . . . .	9
5.2	Acute effects of different training volume on determinants of muscle protein synthesis . . . . .	9
<b>6</b>	<b>General Discussion . . . . .</b>	<b>11</b>
	<b>Conclusion . . . . .</b>	<b>13</b>
	<b>References . . . . .</b>	<b>15</b>

## List of Tables



## List of Figures





1. thesisdown::thesis\_gitbook:  
default

Placeholder



## 2. Background

Placeholder

2.1 Effects of resistance exercise volume on muscle strength and mass

2.2 Ribosomal biogenesis

2.3 Effects of resistance training and resistance training volume on muscle molecular characteristics

2.4 The relationship between muscle mass and strength

2.5 Molecular determinants of training-induced muscle hypertrophy

2.5.1 Protein synthesis

2.5.2 The mammalian target of rapamycin (mTOR) and translational efficiency

2.6 Ribosome biogenesis and muscle growth



### 3. Aims

The primary aim of this thesis was to relate the adaptive response to resistance training with low- and moderate-volume to skeletal-muscle characteristics in previously untrained individuals. The key question was whether manipulation of exercise-volume will have diverse effects in different individuals related to muscular intrinsic characteristics. A further aim was to characterize exercise-volume dependence in muscle molecular characteristics and determine a time course profile of markers of ribosomal biogenesis in response to resistance training. Based on these aims, the objectives of the present thesis were;

- to relate skeletal muscle and systemic characteristics to benefit of moderate-compared to low-volume resistance training;
- To determine volume-dependence in molecular networks related to muscle growth and remodeling in response to resistance training
- To determine a time course of markers related to ribosome biogenesis in the early phase of resistance training.



## 4. Methods

Placeholder

4.1 Study participants, protocols and training interventions

4.2 Resistance training interventions

4.2.1 Ethical considerations

4.3 Muscle strength assessments

4.4 Muscle tissue sampling and preparations for downstream analyses

4.5 Gene expression analysis

4.6 Determination of protein abundance

4.7 Statistics and data analysis

4.8 Gene expression analysis

4.8.1 Normalization





## 5. Results and Discussion

Placeholder

- 5.1 Effects of different training volume on changes in muscle size and function
- 5.2 Acute effects of different training volume on determinants of muscle protein synthesis



## 6. General Discussion



# Conclusion

If we don't want Conclusion to have a chapter number next to it, we can add the `{-}` attribute.

## **More info**

And here's some other random info: the first paragraph after a chapter title or section head *shouldn't be* indented, because indents are to tell the reader that you're starting a new paragraph. Since that's obvious after a chapter or section title, proper typesetting doesn't add an indent there.



# References

Placeholder