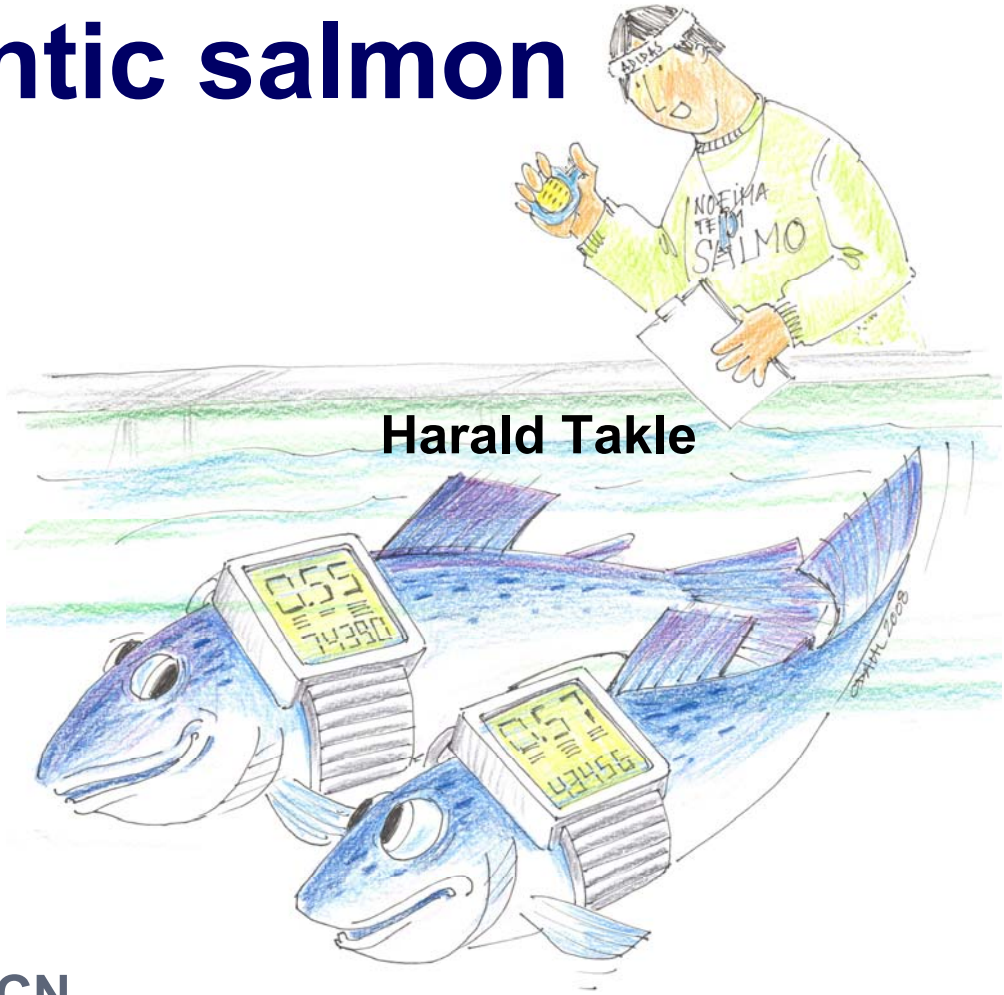
# Exercise training to improve performance and robustness of Atlantic salmon




Funded by FHF and RCN

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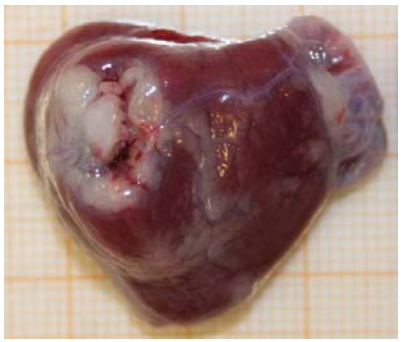
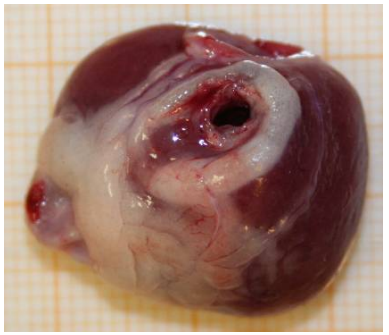
# Background

- Improving robustness of the fish is a key issue in aquaculture
- A fish in good condition perform better:
  - Faster growth with better feed utilization
  - More disease resistant
  - Better welfare

- However! The industry is balancing on the edge of having a sustainable production
  - ISA
  - PD
  - CMS
  - Lice
  - Epicarditis etc
  - Deformities





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# Aim for the project

- Optimize the beneficial effect of aerobic endurance training to improve **growth**, **cardiac performance** and **health** in A. salmon.

- Test different **endurance training programmes** of variable intensities and duration during the freshwater stage and evaluate the training effects on:
  - *cardiac performance and ability to face environmental constraints*
  - *disease resistance* by conducting challenge tests and examine gene responses.
  - *appetite, growth responses and nutrient utilization* by standard nutritional measurements

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# Outline first trial

~50 gr

120 fish per 500 liter tank

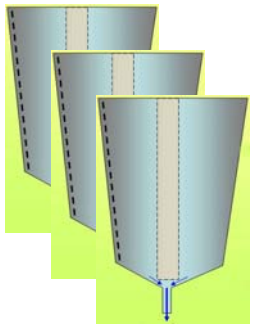
Exercise training
Winter 12L:12D

Recovery
Spring 24L

Salt water

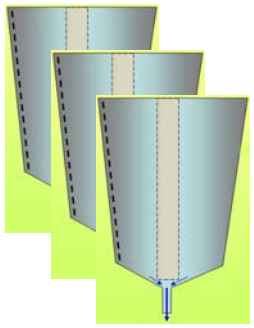
0 | 6 weeks | 6 weeks | 6 weeks

1



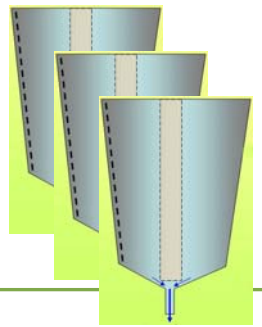
Low intensity continuously:
~ 0.05 bodylength/s$^{-1}$

2



Medium intensity continuously:
~ 0.80 bodylength/s$^{-1}$

3



Medium+ intensity interval:
~ 1.0 bodylength/s$^{-1}$ 8hrs
~ 0.80 bodylength/s$^{-1}$ 16hrs

Fish were pooled and divided in two tanks

Gr 1 transferred to saltwater to examine performance

Gr 2 were challenged with IPN

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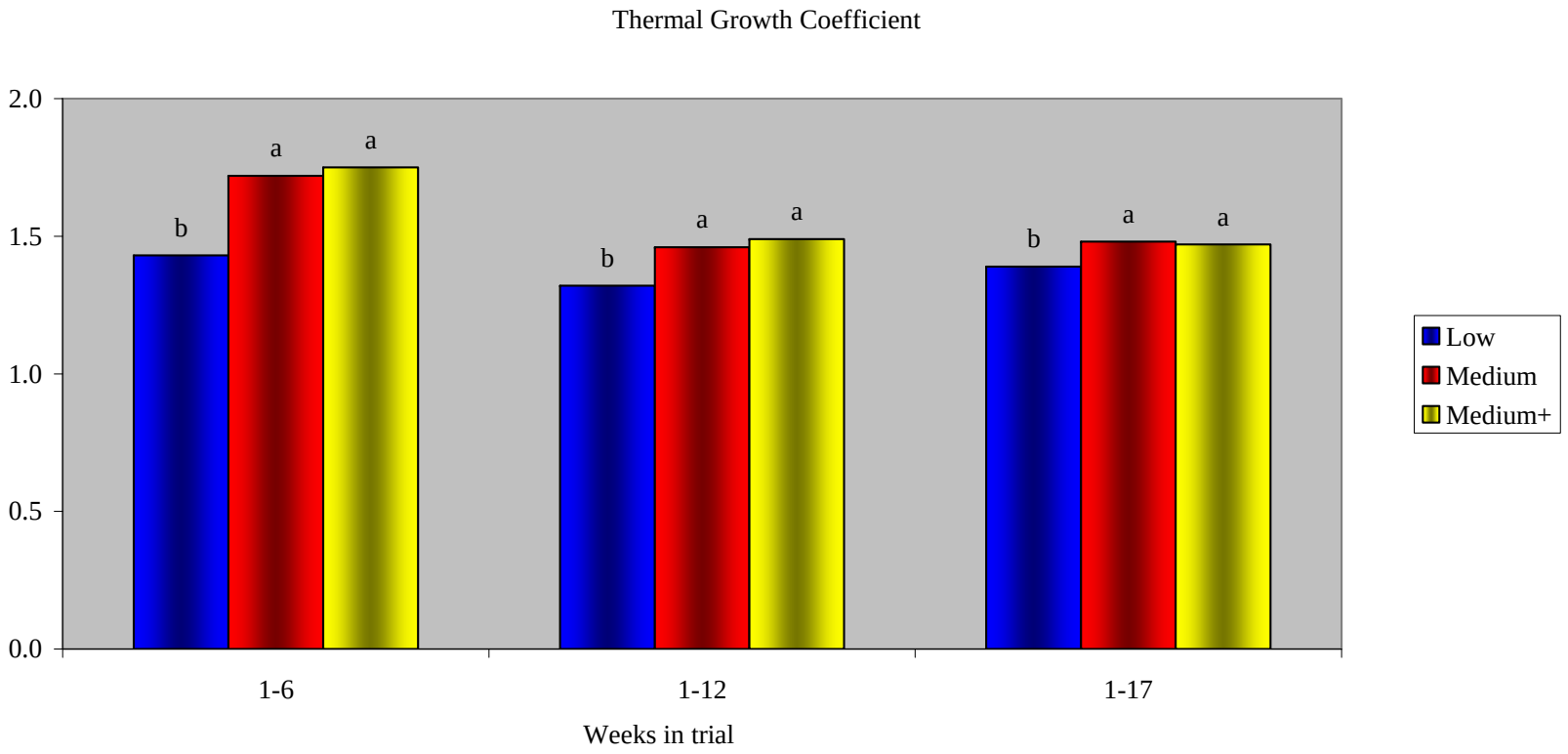
# Growth




- Growth rate improved by 20-22% in exercised fish
- FCR not affected

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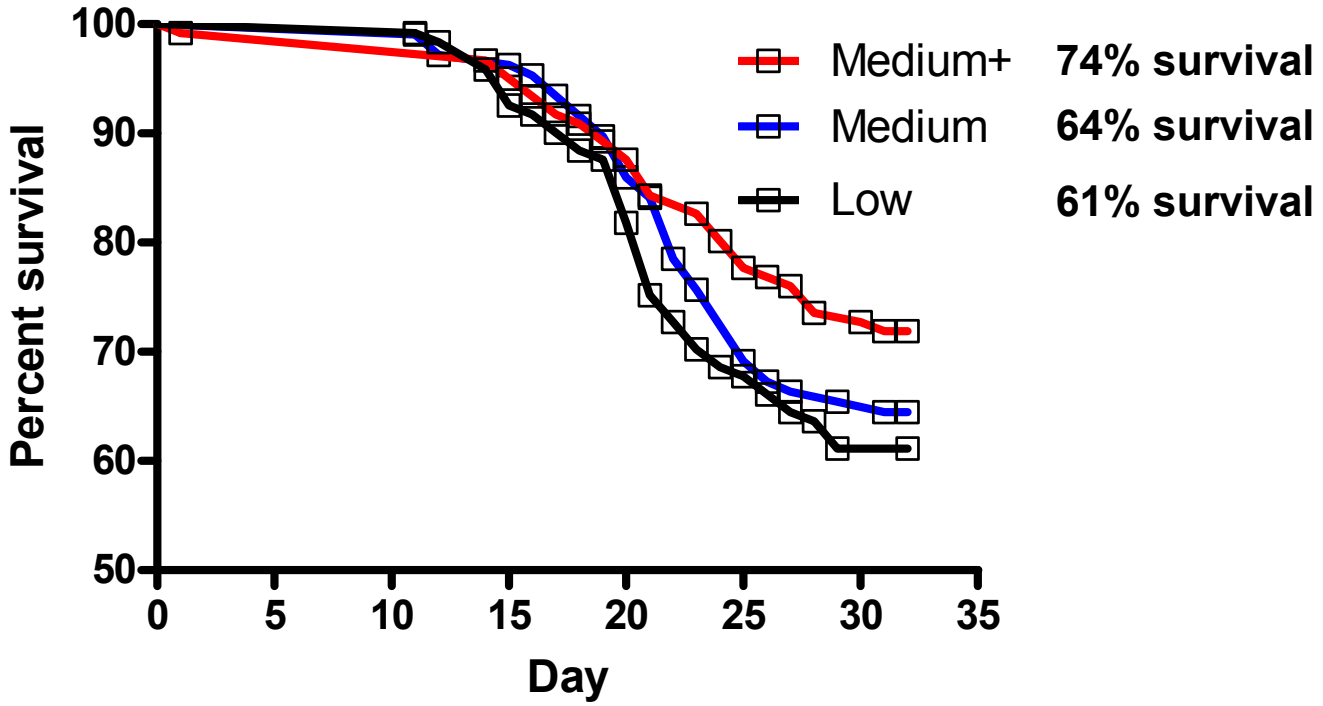
# IPN challenge test




- Could the improved survival of trained fish be explained by a modulation of the immune system?
- Could the difference in survival between M and M+ fish be explained by gene activity?

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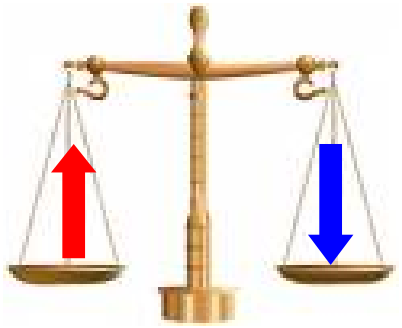
# Exercise and the immune system

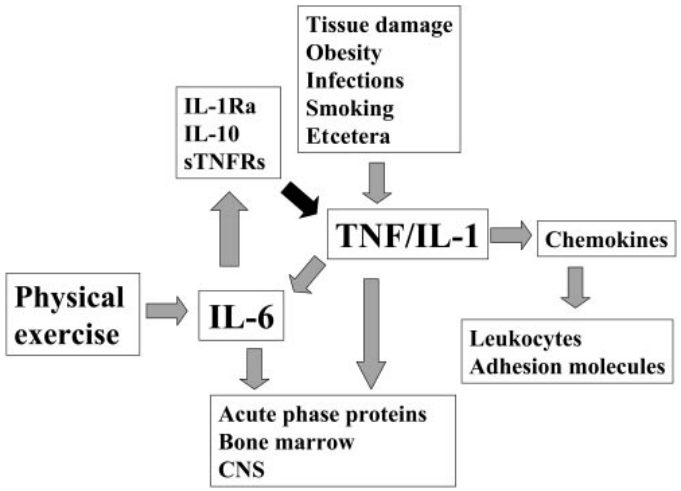
## The burden of low level chronic inflammation

- Inactivity
- Morbidity
- Obesity
- Infections
- High fat intake
- Injury



- Exercise

- Humans:
  - During exercise: TNFα, IL-1β and IL-6 ↑
  - Recovery: TNFα, IL-1β and IL-6 ↓




➢ **How is the situation in salmon?**

Bruunsgaard, 2005

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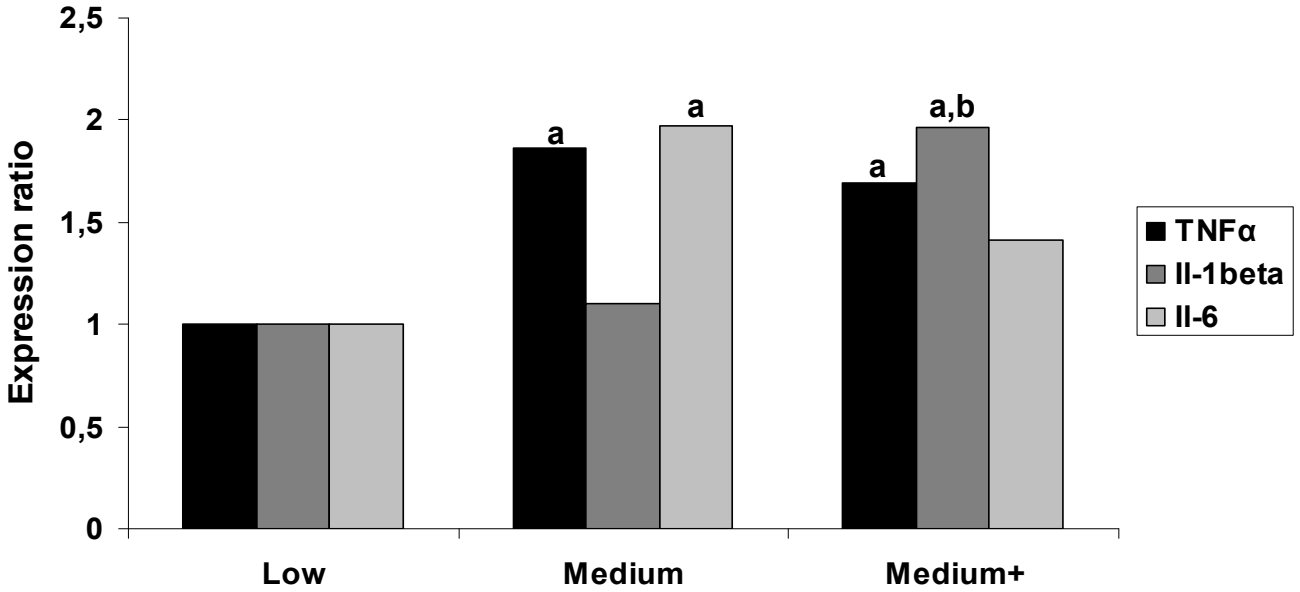
# Exercise and the immune system


- High levels of inflammatory cytokines may reflect cellular stress/damage
- Higher basal inflammatory levels
- No adaptation to exercise yet?

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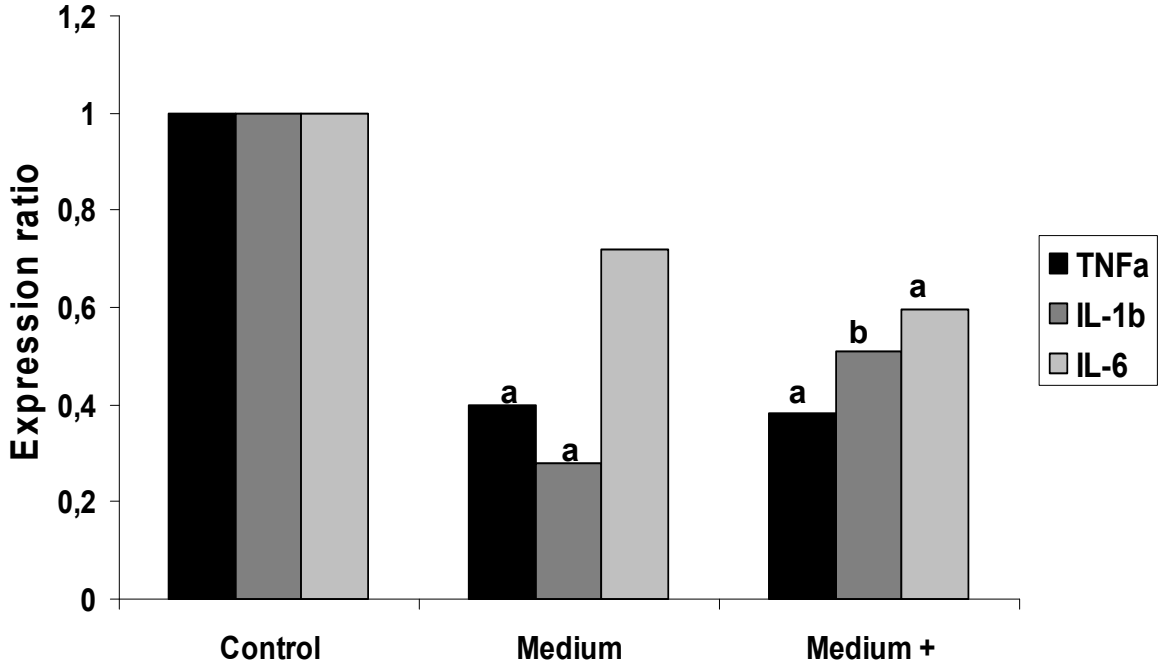
# Exercise and the immune system


- Decreased level of inflammatory status

➢ Improved disease resistance at challenge

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# SFA 2 Microarray (1.8 K; cDNA)


| HEART | Medium | Medium+ | |
|---|---|---|---|
| Inflammation: | ↑ ↓ | ↓ | Eicosanoid pathway and NF-kB pathway |
| Complement: | ↓ | ↑ | First line of host defence:<br>i) amplifying the immune response<br>ii) labeling for destruction<br>iii) killing pathogens |
| Antigen proces. & pres: | – | ↓ | Ubiquitin-Proteasome System and MHC-I<br>→Lowered resting level of antiviral response machinery |
| Adhesion: | – | ↑ | Possibly more immune cells in the heart of M+ fish |
| Antioxidants: | – | ↑ | Better protection against oxidative stress |
| Tissue remodeling: | – | ↑ | Improved cardiac capacity? |

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# FitnessFish exercise training lab

First trial:

Velocity regulated by the inlet water pressure and by the size of the die gap on the inlet pipes

- Little flexibility for interval training
  - Manual adjustments necessary to conduct interval training
- Limited maximum water velocity (17 cm/s)

FitnessFish:

Velocity regulated by individual pumps for each tank

- Great flexibility for interval training
  - Automatic control of the interval programming
  - Fast change of water velocity
- Increased maximum water velocity (27 cm/s)

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~35 g 87 fish per
500 litre tanks

# Outline second trial

S0 (16/09) * Start

Winter 12L:12D — 5 wks

S1 (29/10) *

Spring 24L — 10 wks

S2 (24/11) *

11 wks

S3 (1/12) *

Saltwater

*

S5 (15/12)

IPN challenge

*

14 wks

S4 (22/12)

*

20 wks

S6 (04/02/10)

1 Low intensity continuously:
~0.45 BL/s

~0.45 BL/s-1

2 Medium intensity continuously:
~0.9 BL/s

~0.45 BL/s-1

3 Long interval:
~1.8 BL/s 8hrs
~0.45BL/s 16hrs

~0.45 BL/s-1

4 Short interval:
~1.8 BL/s 8hrs (4x2)
~0.45 BL/s 16hrs

~0.45 BL/s-1

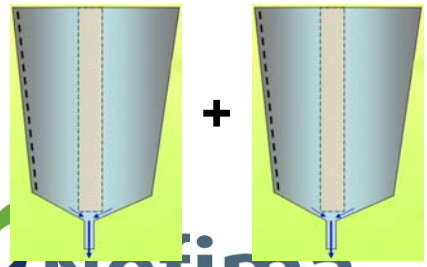
5 High intensity continuously:
~1.8 BL/s 24hrs

~0.45 BL/s-1

END of TRAINING

* Sampling point

IPN + Saltwater



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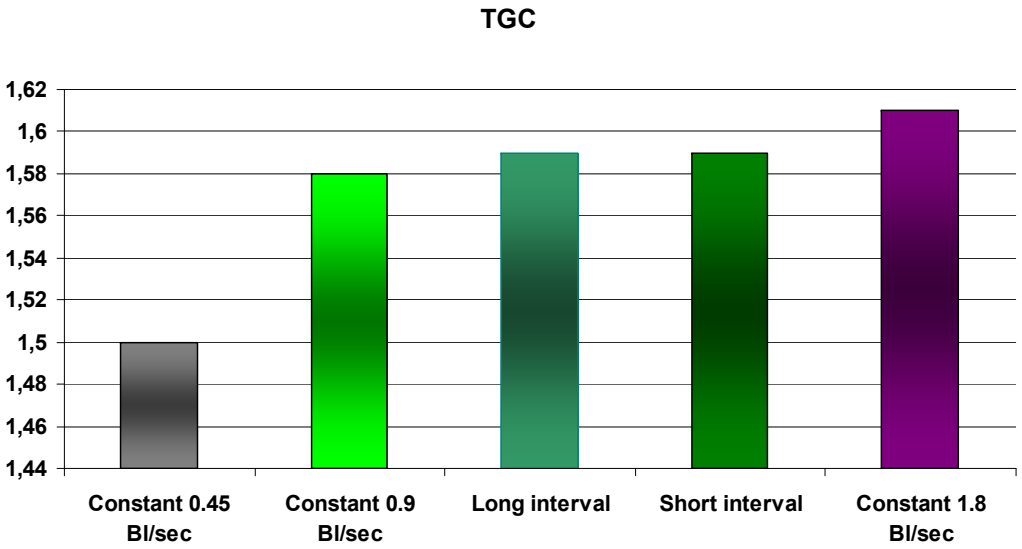
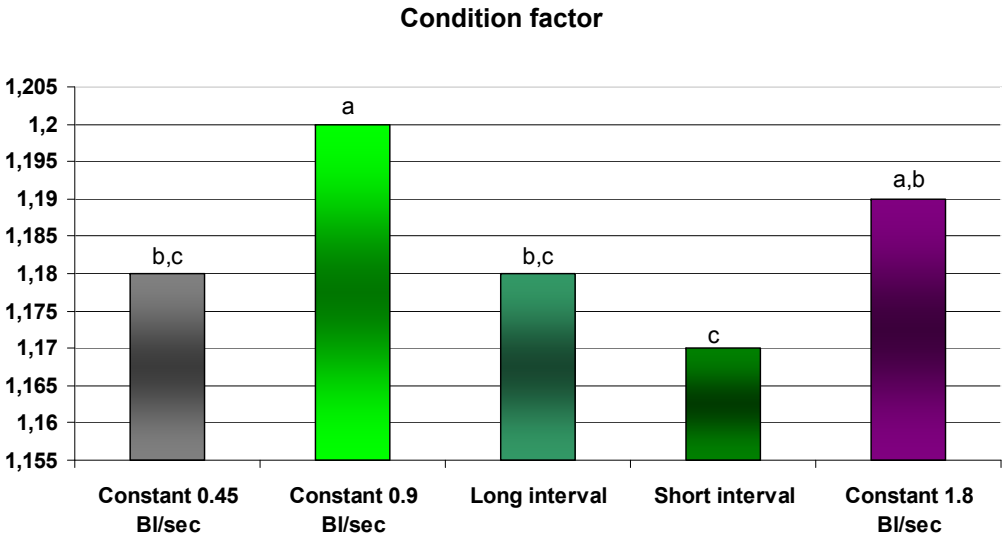
# Growth response

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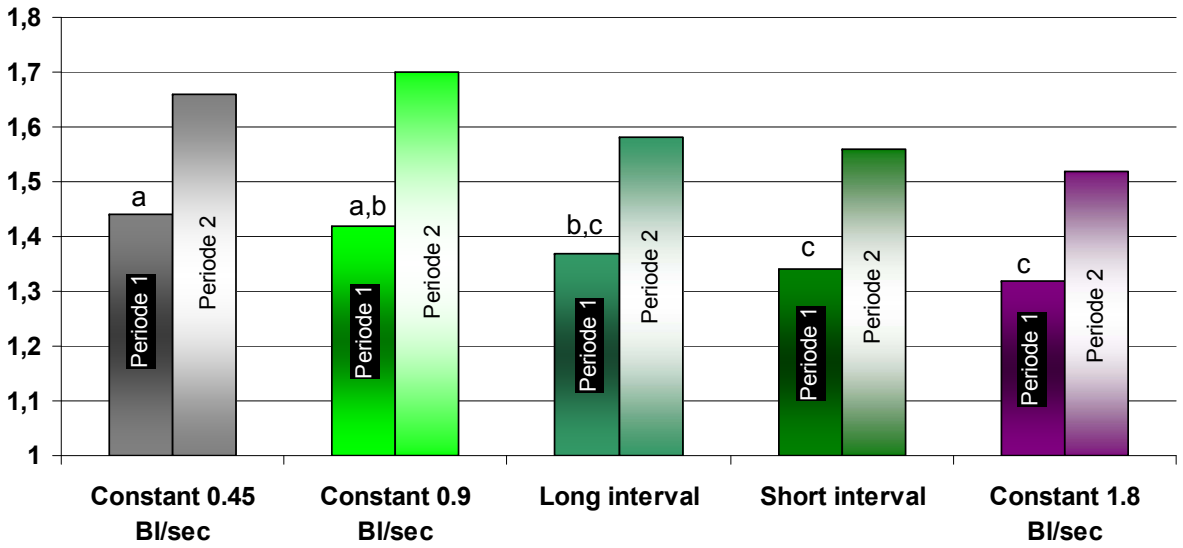
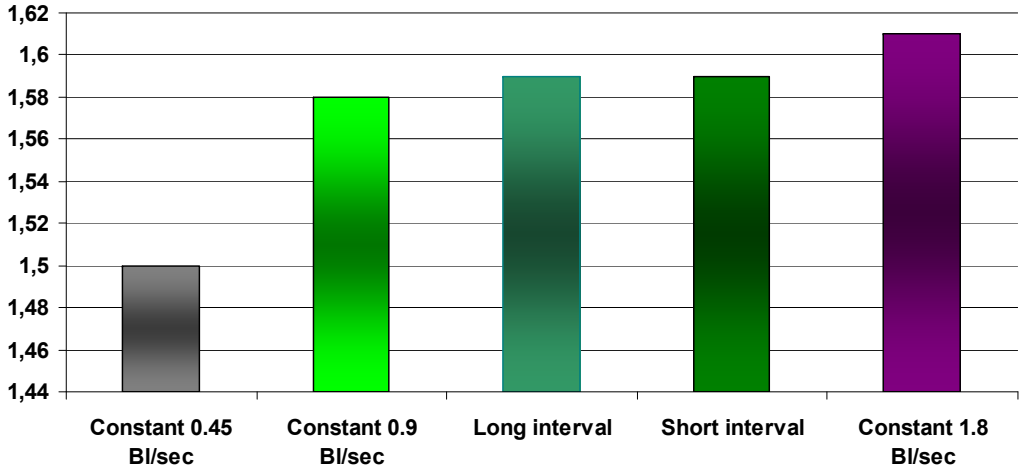
# Growth response

**Feed efficiency**




**TGC**

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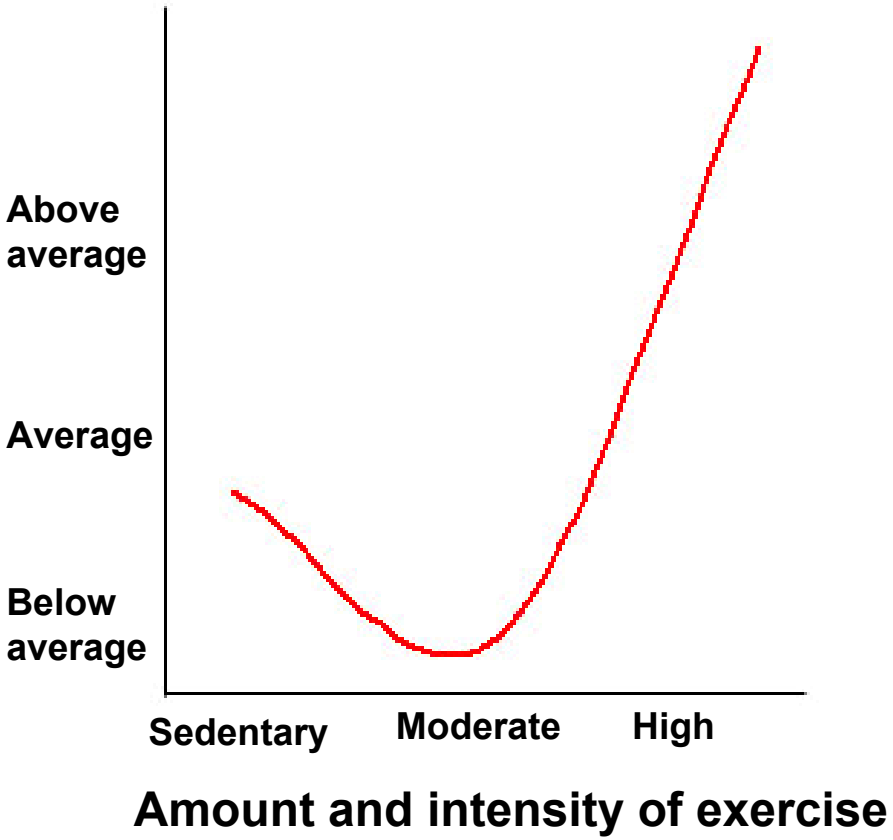
# Exercise intensity and immune function

- Exercise above a certain duration and intensity induce a temporary immunosuppression
- Severe immunosuppression may occur if the immune system are not allowed to recover before a new bout of exercise
- To hard training can result in chronic inflammatory responses and lead to inflammation and disease




➢ **Critical to identify exercise protocols with optimal duration and intensity**

Pedersen et al., 1998; Cooper et al., 2007

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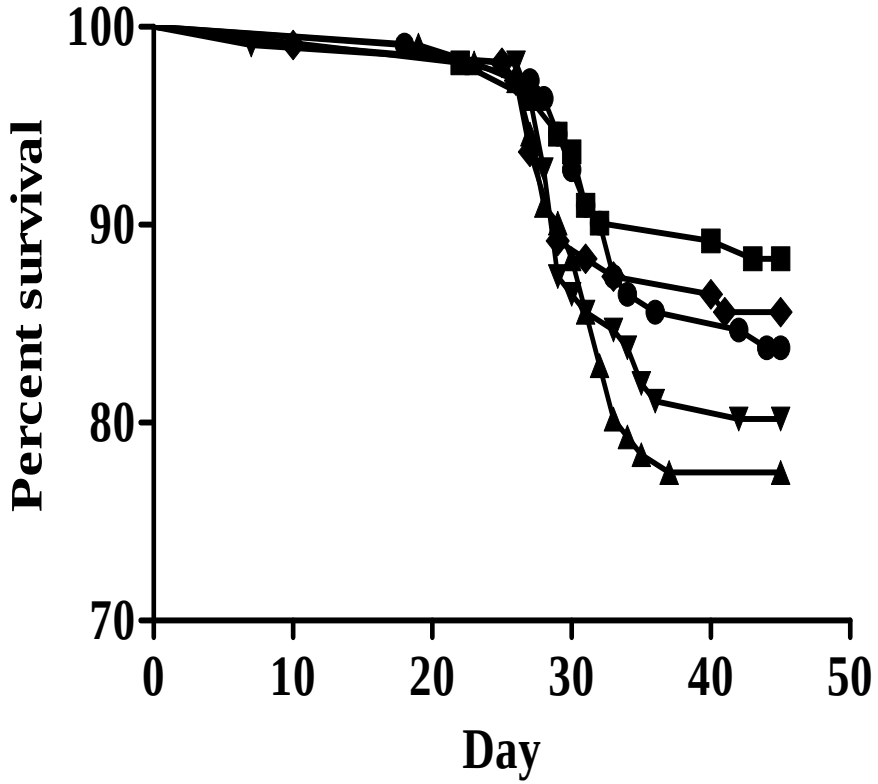
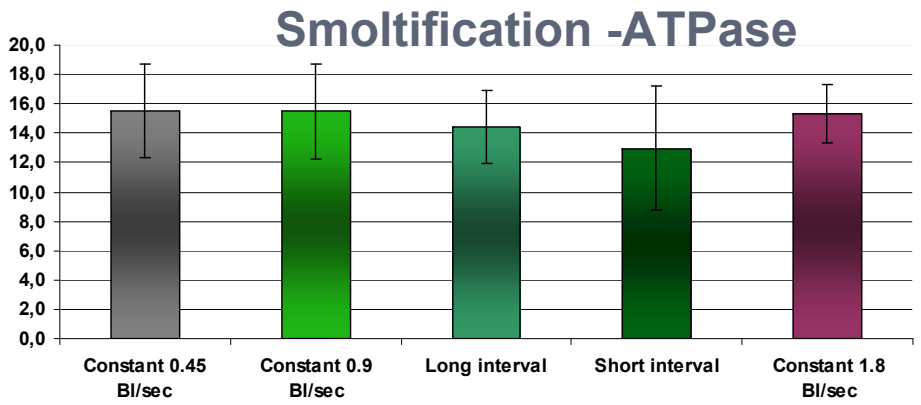
# Effect of exercise in survival in IPN challenge test



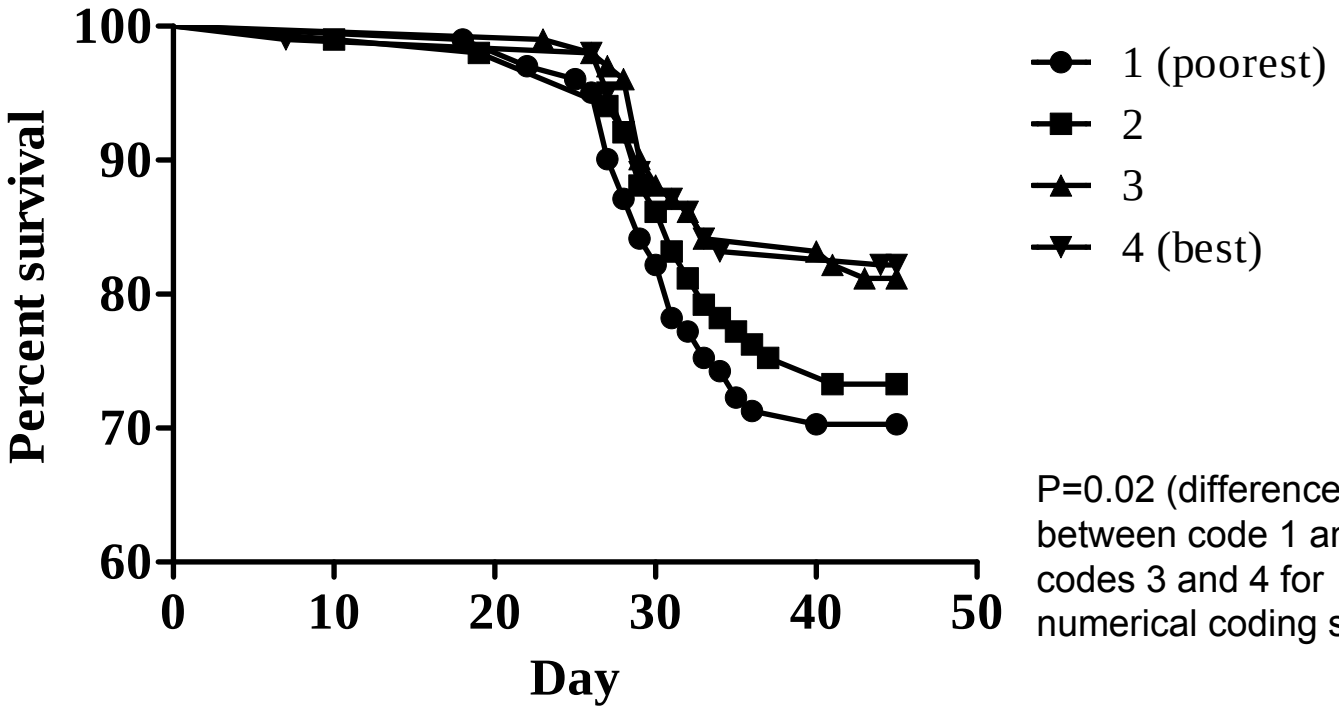

| | |
|---|---|
| Constant medium | 88.3% |
| Constant high | 85.6% |
| Constant low | 83.8% |
| Short interval | 80.2% |
| Long interval | 77.5% |

- Results will be followed up by mRNA and protein expression studies



# Effect of swimming capacity at start of training on survival in IPN challenge test

- Swimming performance tested for all fish at start of trial
- Category 1 till 4 (poor – good swimmers
- Great variation in performance




P=0.02 (difference between code 1 and codes 3 and 4 for numerical coding scale)

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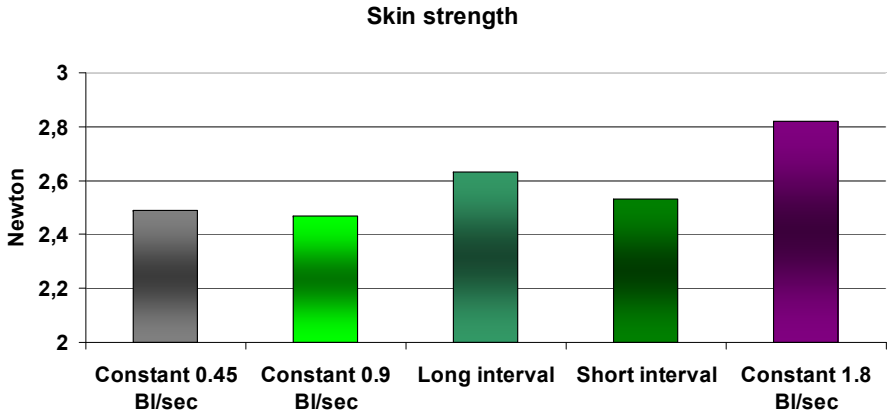
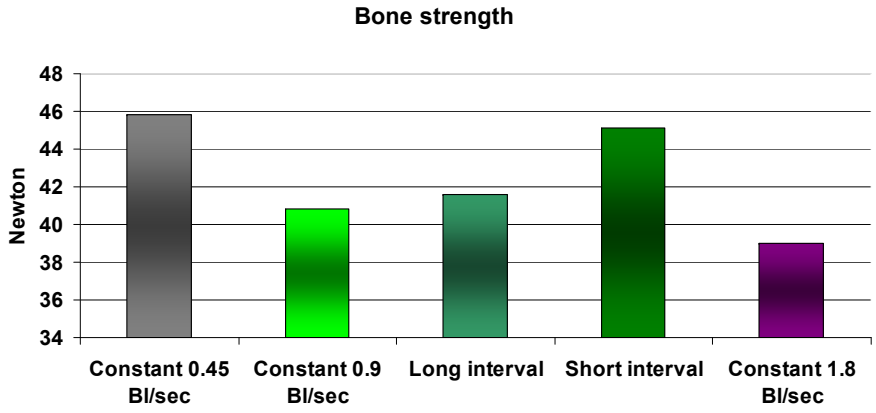
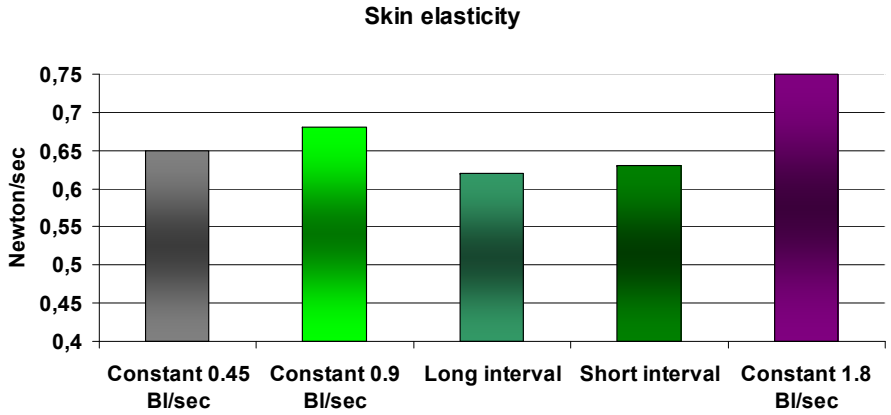
# Quality parameters after 10 weeks of training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# Conclusions

- Exercise training has a positive effect on:
  - Growth
  - Disease resistance, but duration and intensity seems to be essential
  - Immune system
- Great variance in inherited swimming capacity
- Swimming capacity of parr might correspond to disease resistance

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# Contributors

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