Strength-training in soccer

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Why do strength training?

Potential benefits:

“Increase maximal running speed”
“Increase acceleration”
“Increase jumping abilities”
“Increase force in kicking, tackles and headers.”
“Avoid injuries”
What is strength training

Strength training

Transference

Implementation
Strength training

Definition; Training that in a efficient manner induces a measurable increase in strength or/and hypertrophy
Transference

Definition; Training involving exercises that includes maximal or near-maximal muscle-contractions (velocity-specific). Exercises that demand muscle-strength will improve with improved muscle-strength. The exercises that focus on transforming a significant increased in muscle-strength to increased in specific basic movements (increased force in take-off, increased stride length, increased jumping ability, increased eccentric strength in braking etc.)
Definition; Training that involves the actual (or near actual) movements that is performed in the game. The training has focus on implementation of the gains from the transference training to qualities beneficial to the game (Increase stride frequency, increased acceleration, increased running speed, deceleration-capacity, etc.)
What is strength training

Strength training

Transference

Implementation

Strength training

Transference

Implementation
Correlation between muscle force and running speed

Maximal concentric force vs. 100 m time
Force measured during a standardized squat movement.
Best recorded 100 m time
Sprinters

Bret et al., 2002

Short sprint vs. Maximal strength
Force measured during a standardized squat movement.
Best recorded 10 m sprint
Soccer players

Wisløff et al., Br. J. Sports Med., 2004
Do we get slower when doing heavy resistance exercise?

Fig. 3. Peak power-velocity relationships before (full line) and after (dotted line) strength training. Pre to post-training difference, *P < 0.05, **P < 0.01. For definitions of groups see in Fig. 1

HR = Heavy resistance training (8 RM)
LR = Low resistance training (24 RM)
FU = Functional resistance training (~16 RM)
CO = Control, no training

Aagaard et al, 1994
Why do strength training?

.. For our muscles to become stronger

Two way to go…

Improve performance

Increase the size of the muscle mass

Increase the efficiency of the already existing muscle mass

For our muscles to become stronger

Improve performance

Increase the size of the muscle mass

Increase the efficiency of the already existing muscle mass
"Strength-training physiology"
"Explosive" muscle strength

\[ RFD = \frac{\Delta \text{Force}}{\Delta \text{time}} \]

**Figure 1.11 Rate of Force Development (RFD).**
Explosive’ muscle strength: Rate of Force Development

Absolute RFD (Nm/sec)

MVC post = 339 Nm
MVC pre = 291 Nm

Pre training
Post training

RFD
peak
30 ms
50 ms
100 ms
200 ms

Pre
Post

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<th>Pre</th>
<th>Post</th>
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<td>200 ms</td>
<td>1140</td>
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T_{start}

T_{start}

Aagaard, Andersen et al
Muskel fiber typer i humane muskler

- Type I (slow myosin)
- Type IIA (fast myosin)
- Type IIX (very fast myosin)

Muscle

Muscle fibre

Mitochondria

Capillary

Myosin

Zacho og Andersen
Strength-training followed by detraining.
Consequences for muscle fibre CSA

Muscle fiber cross-sectional area

Resistance training

Detraining

Type I fibers

Type II fibers

Andersen et al., unpublished
Fig. 12. Theoretical model of the relationship between relative resistance exercise training intensity (% 1 repetition maximum [%1RM]) and expected degree of muscular hypertrophy.
Hypertrophy in type I and type II fibres after resistance training

Fig. 6. Regression lines representing the relationships between relative (%) hypertrophy of types I, II, IIA and IIB fibres and relative intensity (% 1 repetition maximum [%1RM]) for 16 different resistance exercise training protocols. Regression lines for types I and II fibres are identical to what is seen in figures 4 and 5, while regression lines for types IIA and IIB have been added for the studies accounting for these fibre sub-types. Relative intensity accounts for 12% of the explained variance ($r^2 = 0.124$) for type IIA fibres, and for 20% of the explained variance ($r^2 = 0.202$) for type IIB fibres.\cite{6,8,17,24,25,31,33,34,47-50,59-61}
Muscle fibre adaptations to Strength training

Significant hypertrophy of fast type II fibres
Minor hypertrophy of slow type I fibres
Conversion of fast type IIX fibres to fast type IIA fibres
When designing your strength training

What is most important:

A fast acceleration or high maximal running speed?
Sprint running in a soccer game

They conducted 36±2 sprint (>21 km/h) during a match

Average distance of the sprints were 18 ±1 m, with a peak distance of 38 ±4 m

The average speed of the sprints were 23±0.1 km/h, with a peak average speed of 26 km/t ±0.2 km/h

... but more interestingly the peak velocity reached in the sprints was 31.9 ±0.8 km/h

Comparison, in a test....

Usain Bolt passes 30 m in ~39.5 km/h.
Fast soccer-player passes 30 m in ~35.5 km/h.
Avarage soccer-player passes 30 m in ~34.0 km/h.

Therefore, the players will very seldom reach their maximal running velocity in match situations......

Bangsbo et al, 2006
Thus…. "Fast acceleration may be a more important issue than a high maximal running speed"
Strength training
How much can we improve?

A couple of things to consider……….
What can we achieve by doing strength training?

Adjust your expatiations to reality!

Figure 2.1 The percentage change in maximal squat ability from the pretraining value depends on the pretraining status of the trainees and the duration of training.
“Transfer” or “Carryover”

8 weeks of training,
1 RM increase in squat = 20.9%,
Increase in 40 m sprint time = 2.3%
Carryover = 11%

6 months of training,
Increase in 1 RM leg-press 1 RM = 31.9%,
Increase in 36.7 m sprint time = 6.36%
Carryover = 19.9%
Planning of strength training for soccer players

How it looks in real life
In total 68 games

Additional 0-12 games for the national team
# Training in a week during the match season

## 2 matches in a week

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<th>Sunday</th>
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<td>Pre-game, foot-work, light</td>
<td>Match</td>
<td>Restitution, (Strength-tr.), (no training)</td>
<td>Tactical, aerobic or anaerobic</td>
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<td></td>
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<td>60-75 min</td>
<td>60-90 min.</td>
<td>90-120 min</td>
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### 1 matches in a week

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<td>90-120 min</td>
<td>60-75 min</td>
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Afternoon

**Strength-tr., sprint-drill, jumping**

**90-120 min**
Team resistance training sessions in upstart for a professional soccer team

Andersen, unpublished
Preparation and spring tournament

Træningsgange

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Andersen, unpublished
Autumn tournament

Træningsgange

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Andersen, unpublished
# Preparation and spring tournament

## Squat - repetitioner/vægt

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</table>

Andersen, unpublished
Variables when planning strength training

**Intensity**  
High intensity = Heavy weights/few reps.  
Low intensity = Low weights/many reps.

**Training volume**  
Summation of weights lifted (e.g. tons per week)

**Exercises**  
Choice of exercises, order of exercises etc.

**Sets & Reps.**  
Fixed number (e.g. 3x12), Pyramid, ”decreasing number of reps”, Supersets, ”weight-lifting”

**Breaks**  
Short (5-30 sec. = muscle fatigue), Medium/long (1-2 min. = maximal strength), Long =RFD training

**Contraction velocity**  
Fast/slow, accelerating..

**Type of contraction**  
Concentric, eccentric, isometric

**Micro- Macro-cycles (per iodization)**  
Time between training sessions. Week, months or year cycles
- Accept that strength training and endurance training have to go hand-in-hand.

- Strength training can be conducted throughout the season if planned correctly.

- Post match days (restitution days) can easily be used for maintenance of muscle strength.

- The relatively long season makes it important to focus on maintenance of muscle strength rather than working towards a specific form top (as known form other sports).
Concurrent training

Soccer require skills related to muscle strength, but also demand high anaerobic and aerobic capacity…

Thus, the physical training for soccer players must involve a combination of both strength and endurance qualities…
Concurrent training

Strength training + Endurance training → Net increase in protein synthesis → Muscle hypertrophy

Endurance training + Strength training → Net increase in protein synthesis → Muscle hypertrophy

Andersen, 2011
With caution, the following can be said…:

End your training session/days with the type of training that has the highest priority

If your goal is to optimize muscle strength and muscle hypertrophy; Endurance first, strength last

If your goal is increased endurance –through increased muscle strength, but combined with no or very limited increase in body weight; Strength first, endurance last.

Rule of thumb; “Last impressions last…”
The End
Strength training
Practical approach
During the year........

- **Strength training**
- **Transference**
- **Implementation**

**January**
- Strength training: 80%
- Transference: 15%
- Implementation: 5%

**February**
- Strength training: 70%
- Transference: 20%
- Implementation: 10%

**March**
- Strength training: 50%
- Transference: 30%
- Implementation: 20%

**April**
- Strength training: 40%
- Transference: 40%
- Implementation: 20%

**May**
- Strength training: 40%
- Transference: 40%
- Implementation: 20%

**June**
- Strength training: 50%
- Transference: 20%
- Implementation: 30%

**July**
- Strength training: 60%
- Transference: 20%
- Implementation: 20%

**August**
- Strength training: 30%
- Transference: 30%
- Implementation: 50%

**September**
- Strength training: 40%
- Transference: 40%
- Implementation: 20%

**October**
- Strength training: 48%
- Transference: 14%
- Implementation: 38%

**November**
- Strength training: 50%
- Transference: 20%
- Implementation: 30%

**December**
- Strength training: 60%
- Transference: 30%
- Implementation: 10%
Where are the others when the fastest player are at 20 m?
Variation in number of type 1 fibres in normal healthy subjects

Type 1 fibres in m. vastus lateralis

21 normale unge utrænede mænd

Subjects

Percentage

E K A F O U J H B C D M I P G R S T Q N L

Subjects
Neural adaptations to strength training

Increased neural drive to muscle fibres (increase in EMG)
...more nerve impulses from brain / spinal cord (Moritani & DeVries 1979, Narici et al. 1989, Aagaard et al. 2000)

More synchronized patterns of motoneuron firing
... motoneurons are activated more synchronously (Milner-Brown et al. 1975)

Enhanced neural drive at onset of muscle contraction
... more nerve impulses, elevated impulse frequency, initial 0-200 msec of contraction

Increased rate of EMG rise (RER) (Schmidtleicher & Buehrle 1987, Aagaard et al. 1999)

Reduced neural inhibition in eccentric contraction
... more nerve impulses from the brain / spinal cord (Aagaard et al. 2000)

Increased motoneurone firing frequency (Kamen et al 1998, Van Cutsem et al. 1998)

More synchronized activation of synergist muscles (Moritani 1993)

Motoneuron firing: increased incidence of discharge ‘doublets’
(Van Cutsem et al. 1998)

Enhanced motoneurone excitability (H-reflex, V-wave)
... neurons more sensitive to a given synaptic input (Sale et al 1983, Aagaard et al. 1997, 1998)
m. vastus lateralis

m. soleus

m. triceps brachii
Contraction velocity in different muscles

Sol = soleus
VL = vastus lateralis
TB = triceps brachii

Harridge, 1996
Differences between people

vastus lateralis

Fast fibres =  
Slow fibres =  

deltiod
**Classical description**

- $x_1$, load magnitude
- $x_2$, number of repetitions
- $x_3$, number of sets
- $x_4$, rest in-between sets ([s] or [min])
- $x_5$, number of exercise interventions (per [d] or week)
- $x_6$, duration of the experimental period ([d] or weeks)

- $x_7$, fractional and temporal distribution of the contraction modes per repetition and duration [s] of one repetition
- $x_8$, rest in-between repetitions ([s] or [min])
- $x_9$, time under tension ([s] or [min])
- $x_{10}$, volitional muscular failure
- $x_{11}$, range of motion
- $x_{12}$, recovery time in-between exercise sessions ([h] or [d])
- $x_{13}$, anatomical definition of the exercise (exercise form)

**Table**

<table>
<thead>
<tr>
<th>$x_1$</th>
<th>$x_2$</th>
<th>$x_3$</th>
<th>$x_4$</th>
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**"Missing" description**

**Same description... different training**

Toigo & Boutellier, 2006
## Autumn tournament

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<th>Vægt</th>
<th>08-2008</th>
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Andersen, unpublished