Kompressionsbekleidung

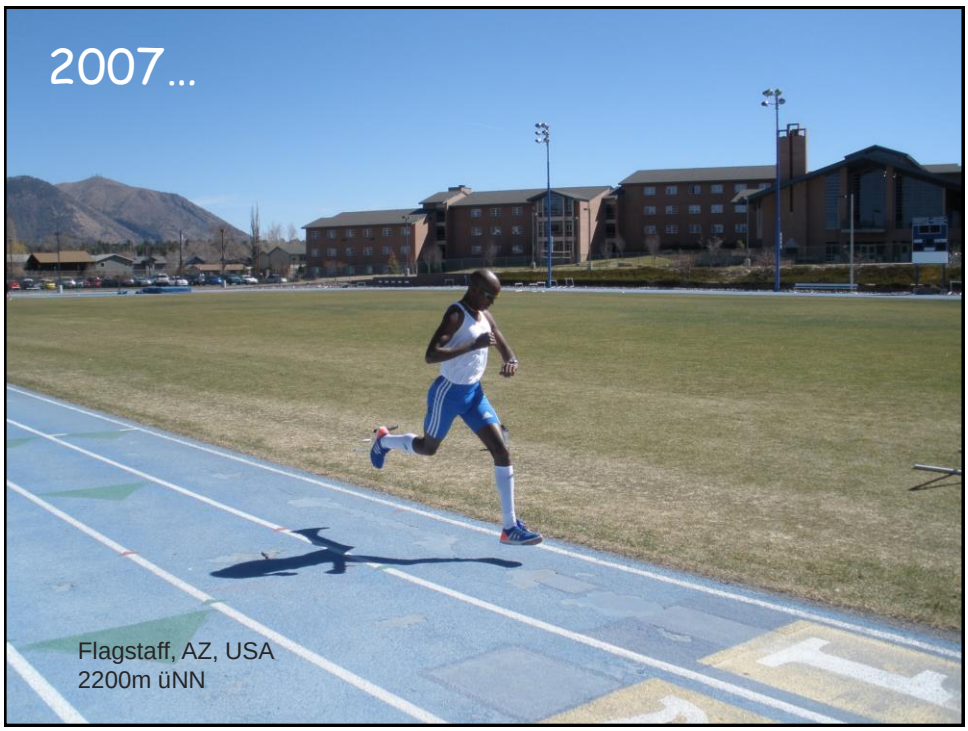
Anwendbarkeit und Limitation zur Leistungs- & Regenerationsförderung

Billy Sperlich

Integrative & Experimental Exercise Science & Training
University of Würzburg, Germany

Finanzielle Interessen und Beziehungen, wie Patente, Honorare oder Unterstützung durch Firmen: Nike, Puma, Sigvaris, Craft, Tchibo

1

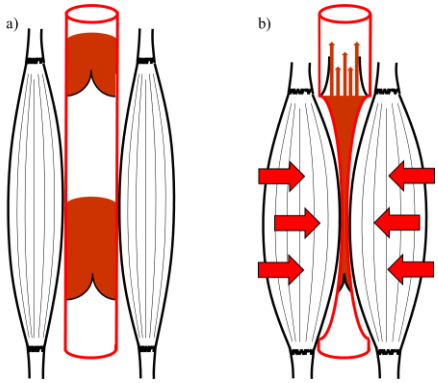


2

Herkunft der Kompressionsbekleidung

- Klinische Studien bei Patienten mit venöser Insuffizienz:
  → gesteigerter Blutfluss mittels Kompressionsbekleidung

Agu et al. 2004
Ibegbuna et al. 2003
Lawrance et al. 1980
Lewis et al. 1976



- Umverteilung vom oberflächlichen in das tiefere Venensystem
- Verbesserte Funktion der Muskelpumpe
- Erhöhter venöser Blutfluss
- Erhöhte Muskeloxygenierung

3

Different types of compression clothing do not increase sub-maximal and maximal endurance performance in well-trained athletes

BILLY SPERLICH[1], MATTHIAS HAEGELE[1], SILVIA ACHTZEHN[1], JOHN LINVILLE[2], HANS-CHRISTER HOLMBERG[3], & JOACHIM MESTER[1]

15 Ausdauerathleten
(VO_{2max}: 63.7+4.9 ml/min/kg)
15 min bei 70% VO_{2max}
+ maximale Ausbelastung

Table I. Responses of different physiological and perceptual values when wearing different types of compression clothing at different time points (mean ± σ).

Variable		Compression				Best effect size	Best *P*
		None	Socks	Tights	Whole-body		
Oxygen uptake (ml · kg^{-1} · min^{-1})	rest	4.9 ± 1.3	5.1 ± 0.7	5.1 ± 0.7	5.0 ± 0.8	0.19	0.60
	submax	41.1 ± 5.6	41.6 ± 7.1	40.8 ± 6.7	40.1 ± 6.6	0.21	0.22
	max	59.8 ± 13.6	62.9 ± 7.3	60.3 ± 8.9	61.1 ± 8.6	0.31	0.26
Lactate (mmol · l^{-1})	rest	0.80 ± 0.19	0.90 ± 0.38	1.12 ± 0.43	0.95 ± 0.25	0.96	0.09
	submax	1.50 ± 0.44	1.53 ± 0.43	1.64 ± 0.41	1.56 ± 0.48	0.33	0.20
	max	7.59 ± 2.88	7.30 ± 2.28	7.64 ± 2.45	7.11 ± 2.11	0.23	0.16
Oxygen saturation (%)	rest	96.3 ± 0.6	96.5 ± 1.1	96.6 ± 0.9	96.8 ± 1.1	0.57	0.13
	submax	95.7 ± 0.9	96.0 ± 0.8	95.9 ± 1.1	96.1 ± 1.2	0.38	0.22
	max	95.6 ± 1.3	95.3 ± 1.2	95.4 ± 1.4	95.6 ± 1.3	0.24	0.26
Oxygen partial pressure (mmHg)	rest	78.8 ± 4.5	81.9 ± 4.5	80.5 ± 4.6	82.3 ± 6.6	0.69	0.09
	submax	75.8 ± 4.2	77.4 ± 5.1	77.2 ± 5.3	77.6 ± 4.1	0.43	0.20
	max	81.2 ± 5.3	80.9 ± 5.0	81.9 ± 5.2	83.4 ± 6.1	0.45	0.09
pH	rest	7.40 ± 0.01	7.40 ± 0.02	7.40 ± 0.02	7.40 ± 0.02	0.00	0.24
	submax	7.40 ± 0.03	7.40 ± 0.02	7.40 ± 0.02	7.40 ± 0.01	0.00	0.23
	max	7.28 ± 0.06	7.30 ± 0.04	7.29 ± 0.05	7.30 ± 0.05	0.39	0.46
Ratings of perceived exertion	submax	13.2 ± 1.5	12.6 ± 1.5	13.1 ± 1.0	12.7 ± 1.1	0.40	0.15
	max	18.6 ± 1.1	18.2 ± 1.1	18.3 ± 1.0	18.4 ± 1.2	0.36	0.10
Ratings of muscle soreness	submax	1.8 ± 0.5	1.8 ± 0.4	1.5 ± 0.4	1.5 ± 0.3	0.85	0.10
	max	2.6 ± 0.7	2.3 ± 0.7	2.6 ± 0.6	2.7 ± 0.6	0.61	0.09
Time to exhaustion (s)	max	310 ± 130	280 ± 76	296 ± 90	281 ± 91	0.28	0.16

Keine Unterschiede in allen erhobenen Parametern
(VO_2, Laktat, Herzfrequenz, Belastungsempfinden, etc.)

4

Original article

Cardio-respiratory and metabolic responses to different levels of compression during submaximal exercise

B Sperlich*, M Haegele*, M Krüger*, T Schiffer†, H-C Holmberg‡§ and J Mester*

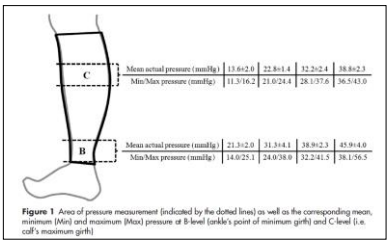
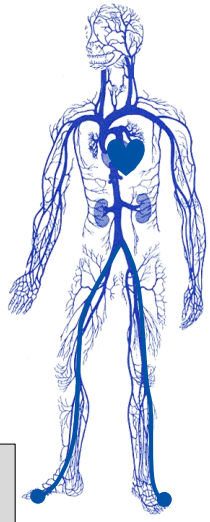


Figure 1 Area of pressure measurement (indicated by the dotted lines) as well as the corresponding mean, minimum (Min) and maximum (Max) pressure at B-level (ankle's point of minimum girth) and C-level (i.e. calf's maximum girth).

15 Läufer (VO_{2max}: 57.2+4.0 mL/min/kg)
➔ Läufe bei 70% VO_{2max} mit 0, 10, 20, 30, 40 mmHg Druck auf den Wadenbauch



Keine Unterschiede in
Schlagvolumen, a-v DO_2, VO_2, O_2-Sättigung, Herzfrequenz und Blutlaktat, etc.

5

Literaturrecherche Born et al. 2013

PubMed National Library of Medicine NLM

33 Studien „Compression & exercise“

Performance

- Max. power/strength
- Sprint
- Jumping height
- TLim
- VO_2
- VO_{2max}
- HR
- pO_2, SO_2
- Lactate
- RPE

Recovery

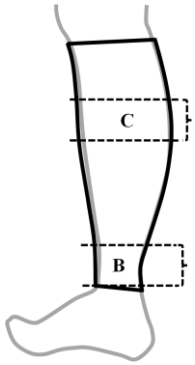
- Recovery of max. strength/power
- Recovery of sprinting
- Recovery of jumping heigth
- Body temperature
- Creatin kinase
- Further marker of muscle damage
- Lactate
- Plasma pH
- HR
- Muscle swelling
- DOMS

Sperlich et al. 2011
Ali et al. 2010
Duffield et al. 2010
Jakeman et al. 2010a
Jakeman et al. 2010b
Kraemer et al. 2010
Sear et al. 2010
Sperlich et al. 2010
Davies et al. 2009
Higgins et al. 2009
Houghton et al. 2009
Kemmler et al. 2009
Pearce et al. 2009
Silver et al. 2009
Duffield et al. 2008
French et al. 2008
Montgomery et al. 2008a
Montgomery et al. 2008b
Scanlan et al. 2008
Ali et al. 2007
Duffield et al. 2007
Bringard et al. 2006
Gill et al. 2006
Maton et al. 2006
Trenell et al. 2006
Bernhardt et al. 2005
Chatard et al. 2004
Doan et al. 2003
Kraemer et al. 2001a
Kraemer et al. 2001b
Kraemer et al. 1998
Kraemer et al. 1996
Berry et al. 1987

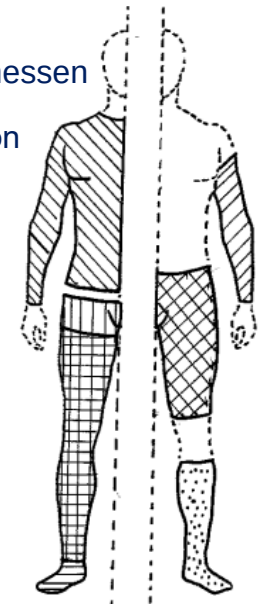
6

Kompressionsarten

- 18 Studien die den Druck tatsächlich messen
- 10 Studien mit „gradueller“ Kompression



Sperlich et al. 2010, 2011



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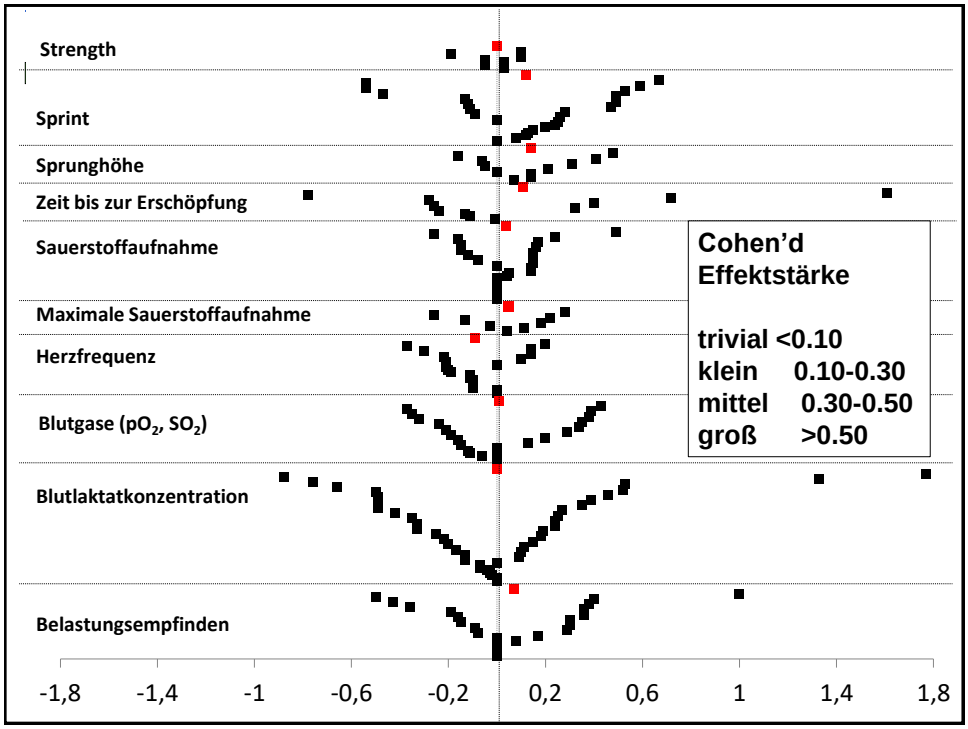
Strength
Sprint
Sprunghöhe
Zeit bis zur Erschöpfung
Sauerstoffaufnahme
Maximale Sauerstoffaufnahme
Herzfrequenz
Blutgase (pO_2, SO_2)
Blutlaktatkonzentration
Belastungsempfinden
-1,8
-1,4
-1
-0,6
-0,2
0,2
0,6
1
1,4
1,8
Cohen'd
Effektstärke
trivial <0.10
klein 0.10-0.30
mittel 0.30-0.50
groß >0.50

9


International Journal of Sports Physiology and Performance, 2013, 8, 4-18
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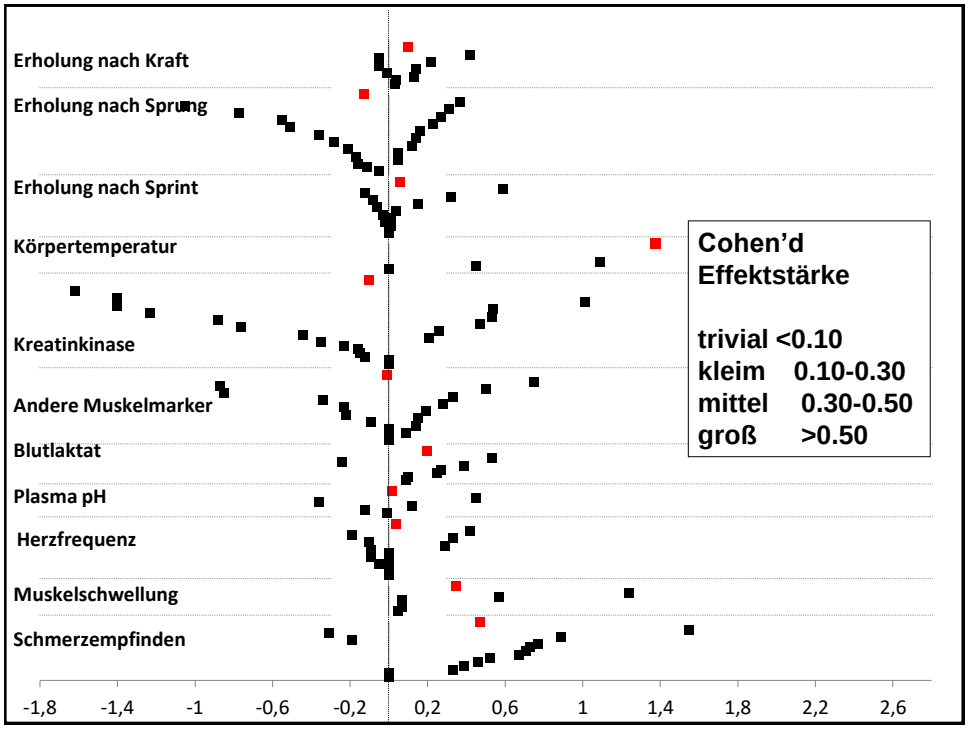
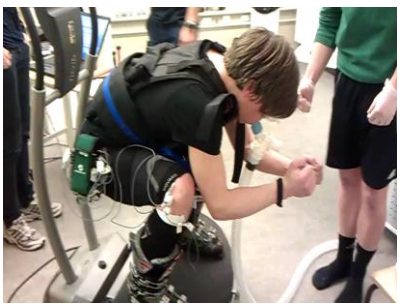
INTERNATIONAL JOURNAL OF
SPORTS PHYSIOLOGY
AND PERFORMANCE
www.IJSPP-Journal.com
BRIEF REVIEW
Bringing Light Into the Dark: Effects of Compression Clothing on Performance and Recovery
Dennis-Peter Born, Billy Sperlich, and Hans-Christer Holmberg
Kompression & „Erholung“

10



11

Beispiel Skifahren




Sperlich et al. BMC Sports Science, Medicine, and Rehabilitation 2013, 5:18
http://biomedcentral.com/2052-1847/5/18

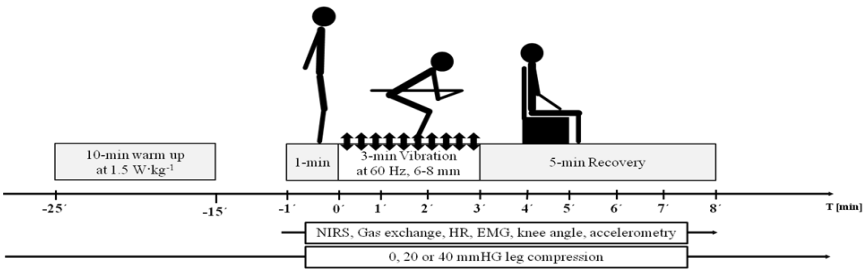
BMC Sports Science, Medicine & Rehabilitation

RESEARCH ARTICLE Open Access

Is leg compression beneficial for alpine skiers?

Billy Sperlich*, Dennis-Peter Born, Mikael Swarén, Yvonne Kilian, Björn Geesmann, Matthias Kohl-Bareis and Hans-Christer Holmberg

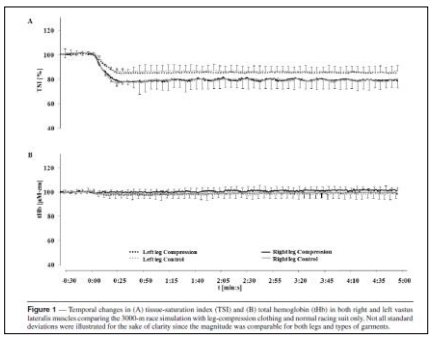
Mit Kompression:
- Kniewinkel -10°
- Weniger Muskeloszillation (-20-25%)
- Weniger Muskelschmerz



12

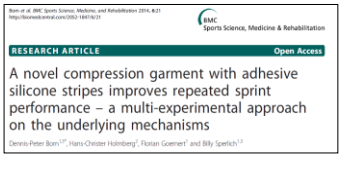
Super Slow Motion – Muscle Vibration

13



"Elite ice speed skaters show an asymmetry in tissue oxygenation of both vastus lateralis muscles during 3000 m events remaining during the long gliding phases along the straight sections of the track. Based on our data, we conclude no performance enhancing benefits from wearing leg compression under a normal racing suit."

14

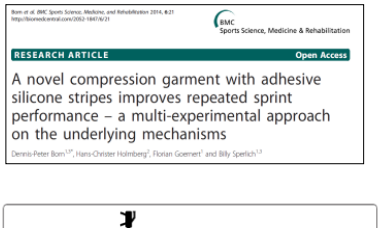

BMC Sports Science, Medicine & Rehabilitation

RESEARCH ARTICLE Open Access

A novel compression garment with adhesive silicone stripes improves repeated sprint performance – a multi-experimental approach on the underlying mechanisms

Dennis-Peter Born[1,3*], Hans-Christer Holmberg[2], Florian Goernert[1] and Billy Sperlich[1,3]

15


BMC Sports Science, Medicine & Rehabilitation

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A novel compression garment with adhesive silicone stripes improves repeated sprint performance – a multi-experimental approach on the underlying mechanisms

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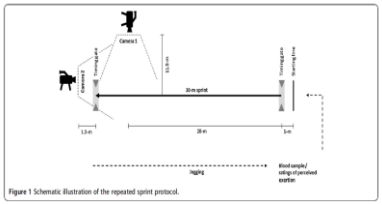
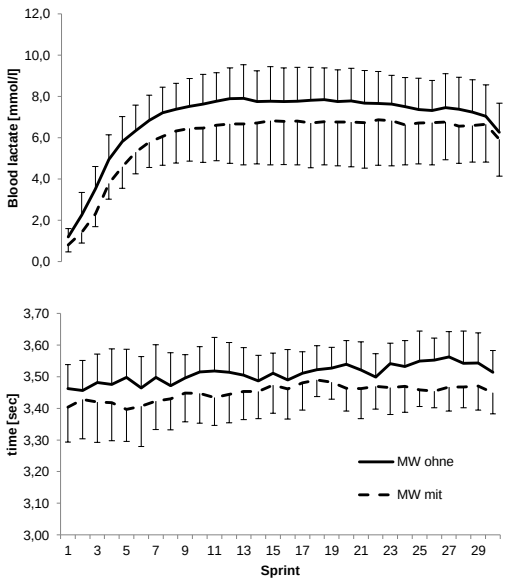


Figure 1 Schematic illustration of the repeated sprint protocol.



16

Am J Physiol Regul Integr Comp Physiol 289: R1448–R1458, 2005.
First published May 26, 2005; doi:10.1152/ajpregu.00824.2004.

Why do arms extract less oxygen than legs during exercise?

J. A. L. Calbet,[1,2] H.-C. Holmberg,[3] H. Rosdahl,[4] G. van Hall,[2] M. Jensen-Urstad,[5] and B. Saltin[2]
[1]*Department of Physical Education, University of Las Palmas de Gran Canaria, Canary Islands, Spain;*
[2]*The Copenhagen Muscle Research Center, Rigshospitalet, Copenhagen, Denmark; Departments of*
[3]*Physiology-Pharmacology and* [4]*Cardiology, Karolinska Institute, Stockholm; and* [5]*Department of*
Sport and Health Sciences, University College of Physical Education and Sports, Stockholm, Sweden

Submitted 6 December 2004; accepted in final form 13 May 2005

Because conditions for O2 off-loading from the hemoglobin are similar in leg and arm muscles, the observed differences in maximal arm and leg O2 extraction should be attributed to other factors, such as a **higher heterogeneity in blood flow distribution, shorter mean transit time, smaller diffusing area, and larger diffusing distance, in arms than in legs.**

17

International Journal of Sports Physiology and Performance, 2014, 9, 48-57
http://dx.doi.org/10.1123/IJSPP.2013-0137
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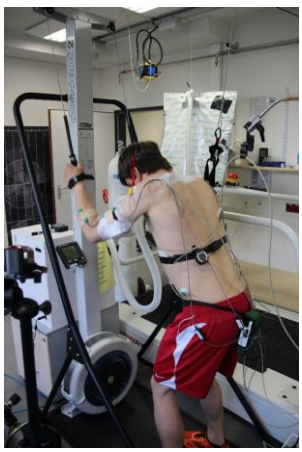
INTERNATIONAL JOURNAL OF
SPORTS PHYSIOLOGY
AND PERFORMANCE
www.IJSPP-Journal.com
ORIGINAL INVESTIGATION

Does Upper-Body Compression Improve 3 × 3-Min Double-Poling Sprint Performance?

Billy Sperlich, Dennis-Peter Born, Christoph Zinner, Anna Hauser, and Hans-Christer Holmberg

sochi.ru 2014



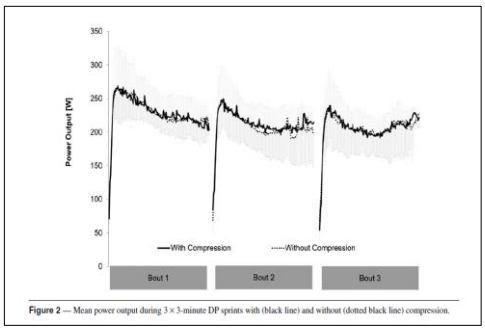


Figure 2 — Mean power output during 3 × 3-minute DP sprints with (black line) and without (dotted black line) compression.

"The authors conclude that the performance of well-trained athletes during 3 × 3-min double poling sprints will not be enhanced by upper-bodycompression."

18

Front Physiol. 2018

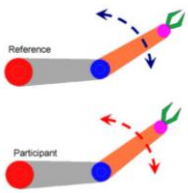
Acute Responses to Forearm Compression of Blood Lactate Accumulation, Heart Rate, Perceived Exertion, and Muscle Pain in Elite Climbers.

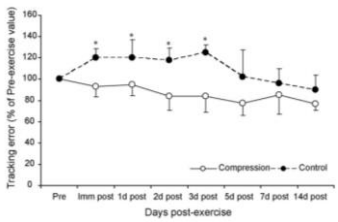
Engel FA[1], Sperlich B[1,2], Stöcker U[3], Wolf P[4], Schöffl V[5], Donath L[6].

Das Tragen von Kompressionssleeves während und nach intensiven Boulderrouten hatte keine oder nur geringfügige Effekte auf Blutlaktat, Herzfrequenz, Belastungsempfinden und Muskelschmerz.

19

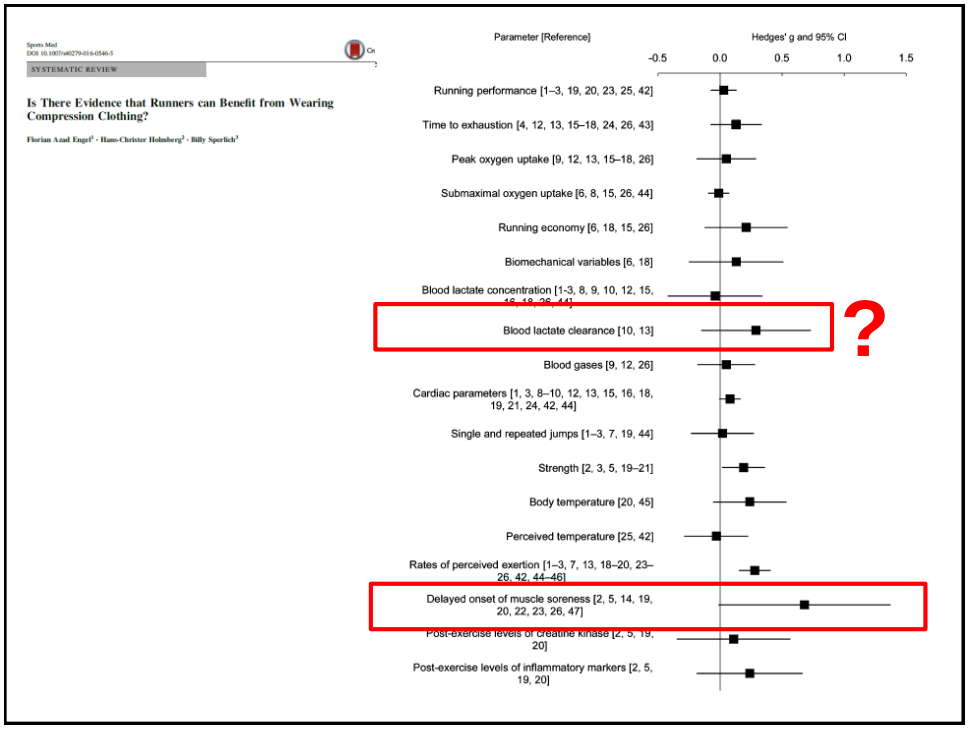
Motor Control - Präzision **(Pearce et al. 2009, J Sci Med Sport)**





"[…] the results suggest that the wearing of sports compression garments post-eccentric exercise has a positive effect on functional motor control."

20


Sports Med
DOI 10.1007/s40279-016-0546-5
SYSTEMATIC REVIEW
Is There Evidence that Runners can Benefit from Wearing Compression Clothing?
Florian A.nd Engel[1] · Hans-Christer Holmberg[2] · Billy Sperlich[3]
Parameter [Reference]
Hedges' g and 95% CI
-0.5
0.0
0.5
1.0
1.5
Running performance [1–3, 19, 20, 23, 25, 42]
Time to exhaustion [4, 12, 13, 15–18, 24, 26, 43]
Peak oxygen uptake [9, 12, 13, 15–18, 26]
Submaximal oxygen uptake [6, 8, 15, 26, 44]
Running economy [6, 18, 15, 26]
Biomechanical variables [6, 18]
Blood lactate concentration [1-3, 8, 9, 10, 12, 15,
Blood lactate clearance [10, 13]
?
Blood gases [9, 12, 26]
Cardiac parameters [1, 3, 8–10, 12, 13, 15, 16, 18, 19, 21, 24, 42, 44]
Single and repeated jumps [1–3, 7, 19, 44]
Strength [2, 3, 5, 19–21]
Body temperature [20, 45]
Perceived temperature [25, 42]
Rates of perceived exertion [1–3, 7, 13, 18–20, 23–26, 42, 44–46]
Delayed onset of muscle soreness [2, 5, 14, 19, 20, 22, 23, 26, 47]
Post-exercise levels of creatine kinase [2, 5, 19, 20]
Post-exercise levels of inflammatory markers [2, 5, 19, 20]

21


Mechanismen
OPEN ACCESS Freely available online
PLOS ONE
Squeezing the Muscle: Compression Clothing and Muscle Metabolism during Recovery from High Intensity Exercise
Billy Sperlich[1,2*], Dennis-Peter Born[1], Kimmo Kaskinoro[3,4], Kari K. Kalliokoski[3], Marko S. Laaksonen[5]
Ramp test
+ 25W·min-1
75% VO2peak
15O-H2O
100 W
15O-H2O
18F-FDG
0
20
40
60
80
100
Time [min]
Injection of Tracer
PET Scan
Blood sample for glucose and lactate
Application of compression
Transmissions Scan
Figure 1. Study design. A schematic illustration with all time points of measurements.
doi:10.1371/journal.pone.0060923.g001
Turun yliopisto
University of Turku

22

Mechanismen

OPEN ACCESS Freely available online
PLOS ONE

Squeezing the Muscle: Compression Clothing and Muscle Metabolism during Recovery from High Intensity Exercise

Billy Sperlich[1,2*], Dennis-Peter Born[1], Kimmo Kaskinoro[3,4], Kari K. Kalliokoski[3], Marko S. Laaksonen[5]

1 Department of Sport Science, University of Wuppertal, Wuppertal, Germany, 2 Department of Sport Science, University AF Munich, Munich, Germany, 3 Turku PET Centre, University of Turku, Turku, Finland, 4 Anesthesiology and Intensive Care, University of Turku, Turku, Finland, 5 Swedish Winter Sports Research Centre, Department of Health Sciences, Mid Sweden University, Östersund, Sweden

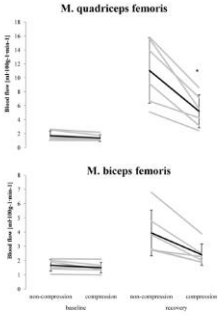


Figure 3. Skeletal muscle blood flow. M. quadriceps femoris (above) and m. biceps femoris (below) without (non-compression) and with compression (compression) during baseline and recovery from high intensity exercise (*indicates statistical significant differences P<0.05).

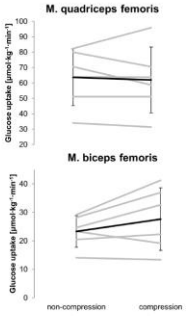
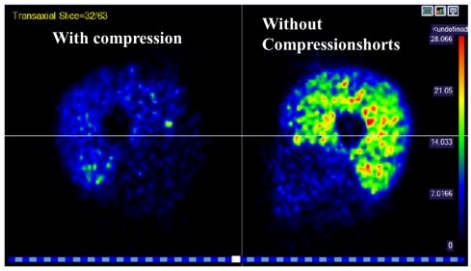


Figure 4. Glucose uptake. M. quadriceps femoris (above) and m. biceps femoris (below) without and with compression during recovery from high intensity exercise.
doi:10.1371/journal.pone.0060923.g004



Turun yliopisto
University of Turku

23

Muscle Nerve. 2017

Effect of resistance training with vibration and compression on the formation of muscle and bone.

Zinner C[1], Baessler B[2], Weiss K[2,3], Ruf J[2], Michels G[4], Holmberg HC[5,6], Sperlich B[1].

12 weeks of resistance training with application of vibration (VIBRA; 1-2 mm, 30 Hz) to both legs and compression (~35 mm Hg, VIBRA+COMP) to only 1 leg.

FIGURE 1. MRI scans of a subject before (**A**, **C**) and after (**B**, **D**) 12 weeks of resistance exercise with vibration and compression (VIBRA+COMP) or vibration alone (VIBRA). (**A**, **B**) Coronal imaging and axial slice (**C**, **D**) through the upper leg from the same MRI. The colors indicate the segmented fat (blue) and muscle (red), and the cortical (aqua) and cancellous (yellow) bone.

24

European Journal of Sport Science, 2017
https://doi.org/10.1080/17461391.2017.1380707

ORIGINAL ARTICLE

Responses of low and high compression during recovery after repeated sprint training in well-trained handball players

CHRISTOPH ZINNER[1], MAXIMILIAN PELKA[2], ALEXANDER FERRAUTI[3], TIM MEYER[4], MARK PFEIFFER[5], & BILLY SPERLICH[1]

REGman

Bundesinstitut für Sportwissenschaft

2. Handball Bundesliga
bis 48h nach 30 x30 m Sprint
0, 10, 25 mmHg Beinkompression

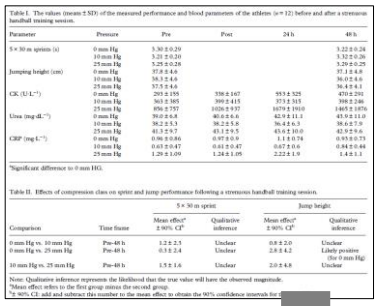


Table I. The values (mean ± SD) of the measured performance and blood parameters of the athletes (n = 12) before and after a strenuous handball training session.

Parameter	Pressure	Pre	Post	24 h	48 h
5 × 30 m sprints (s)	0 mm Hg	5.30 ± 0.29			5.22 ± 0.28
	10 mm Hg	5.21 ± 0.20			5.32 ± 0.26
	25 mm Hg	5.25 ± 0.28			5.29 ± 0.25
Jumping height (cm)	0 mm Hg	37.8 ± 4.6			37.1 ± 4.4
	10 mm Hg	38.3 ± 4.6			36.0 ± 4.6
	25 mm Hg	37.5 ± 4.6			36.4 ± 4.1
CK (U·L^{-1})	0 mm Hg	293 ± 155	338 ± 167	353 ± 325	470 ± 260
	10 mm Hg	363 ± 385	399 ± 415	373 ± 315	398 ± 246
	25 mm Hg	856 ± 757	1026 ± 937	1079 ± 1910	1465 ± 1876
Urea (mg·dL^{-1})	0 mm Hg	39.0 ± 6.8	40.4 ± 6.6	42.9 ± 11.1	43.9 ± 11.0
	10 mm Hg	38.2 ± 5.3	38.2 ± 5.8	36.4 ± 6.3	38.4 ± 7.0
	25 mm Hg	41.3 ± 9.7	43.1 ± 9.5	43.4 ± 10.0	42.9 ± 9.6
CRP (mg·L^{-1})	0 mm Hg	0.96 ± 0.86	0.97 ± 0.9	1.1 ± 0.74	0.93 ± 0.73
	10 mm Hg	0.63 ± 0.47	0.61 ± 0.47	0.67 ± 0.6	0.84 ± 0.48
	25 mm Hg	1.29 ± 1.09	1.24 ± 1.05	2.22 ± 1.9	1.4 ± 1.1

*Significant difference to 0 mm HG.

Table II. Effects of compression class on sprint and jump performance following a strenuous handball training session.

		5 × 30 m sprint		Jump height	
Comparison	Time frame	Mean effect* ± 90% CI[#]	Qualitative inference	Mean effect* ± 90% CI[#]	Qualitative inference
0 mm Hg vs. 10 mm Hg	Pre-48 h	1.2 ± 2.3	Unclear	0.8 ± 2.0	Unclear
0 mm Hg vs. 25 mm Hg	Pre-48 h	0.3 ± 2.4	Unclear	2.8 ± 4.2	Likely positive (for 0 mm Hg)
10 mm Hg vs. 25 mm Hg	Pre-48 h	1.5 ± 1.6	Unclear	2.0 ± 4.8	Unclear

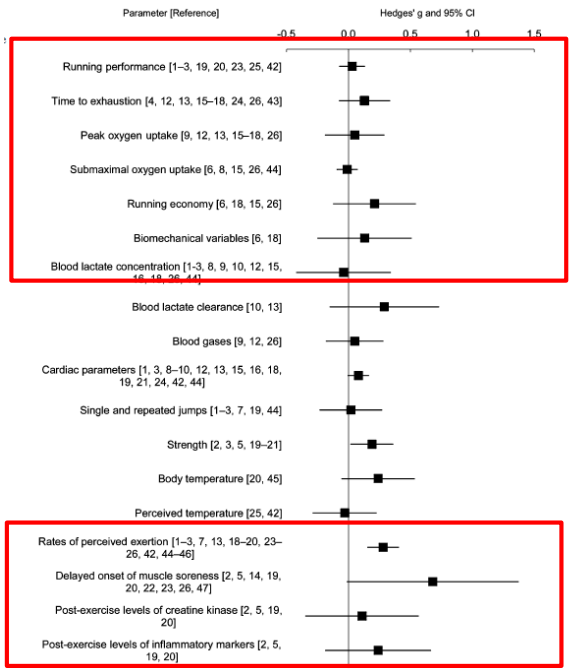
Note: Qualitative inference represents the likelihood that the true value will have the observed magnitude.
*Mean effect refers to the first group minus the second group.
[#]± 90% CI: add and subtract this number to the mean effect to obtain the 90% confidence intervals for the

We conclude that the application of 10 mm Hg leg compression compared to 0 and 25 mm Hg of compression during 48 h of recovery from repeated and exhausting sprints lowered the plasma concentrations of CK and urea with no improvements in recovery for performance.

25

Zusammenfassung

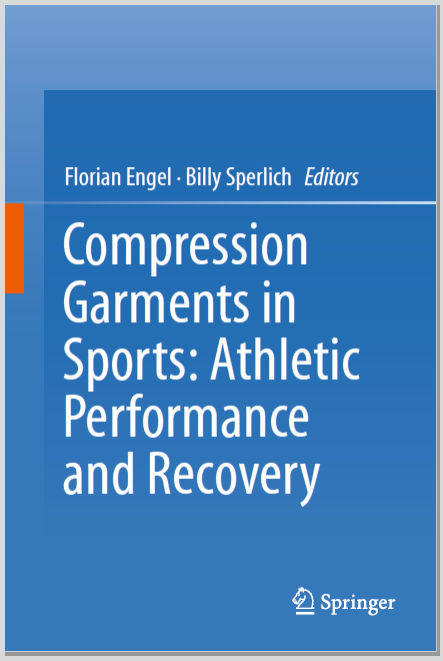
- **Geschmäcker sind unterschiedlich**
- **Unbedingt: Individuell anpassen**
- **Eher für Regeneration**
- **Eher wiederholte Sprint-/Sprungbelastung**
- **Eher Präzision**
- **Weiblich?**
- **Thermoregulation?**



26

Vielen Dank

/billysperlich



27