

Proprioception – Balance – Sensorimotor Training Objectives and Fields of Application



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Introduction

Sensorimotor training (SMT) is often used in athletic training, sports therapy and physiotherapy to enhance performance, to prevent injuries or to treat (sport specific) problems of the neuromuscular system.

Despite the comprehensive application of this training mean in daily practice, evidence-based proofs of the efficiency of those fields of application remain partially unclear.

The purpose of this work is to give a short overview of the efficiency of sensorimotor training to balance assumed objectives with proven scientific evidence.

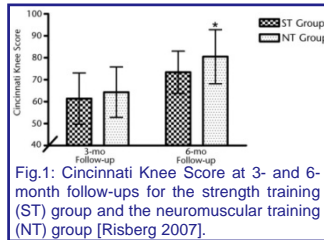
Evidence In Rehabilitation

SMT improves balance and postural control in patients with neurologic disorders (brain injury, stroke, Parkinson's disease) [Bayerk 2007, Chen 2002, Dault 2002, Ebersbach 2008]

Effects of SMT on "functionally unstable ankles" show shortening of muscle reaction time and improved postural sway. A strong need for quality research with acute traumatic injury patients is evident. [Clark & Burden 2005, Osborne 2001, McKeon 2008, Rozzi 1999, Holme 1999]

Many studies use mixed therapy approaches. Single effect of SMT is therefore often not identifiable. [Trees 2002, 2005]

Risberg et al. conclude that "neuromuscular training" (SMT) is superior to strength training in improving knee function in ACL-rehabilitation. Probably the first study assessing isolated effects of SMT compared to standard therapy procedures. [Risberg 2007 – see Fig. 1]



SMT may be beneficial in the treatment of overuse injury [Müller 2008]

Evidence in prevention

First significant contributions on preventive effects of SMT were published in the 1990s. Nevertheless a Cochrane Review by Handoll et al. concluded in 2000 that SMT warrants further research to quantify the effects of SMT. [Bahr 1997, Caraffa 1996, Handoll 2000]

RCTs show recently clear evidence that SMT:

- reduces overall injury risk (lower extremity). [Olson 2005, Pasanen 2008]
- reduces the incidence of ankle injuries (Fig1 - right).
- reduces the incidence of ACL injuries

[Gilchrist 2008, Mandelbaum 2005, Myklebust 2003]

Training routines apply a high training frequency initially during the first phase of intervention (preseason) and then a reduced training load later on (home-based training, inseason).

[Emery 2005, 2007, McGuire 2006, McHugh 2007, Myklebust 2003, Olson 2005, Fig.2]

Adverse effects (increase of certain injuries) have to be kept in mind. [Verhagen 2004, Södermann 2000]

Benefits of SMT on upper extremity function suggest clinical effectiveness - knowledge is still limited. [Lehmann 2006, Naughton 2005]

Literature

(key references – full list available by contacting the author):

Bruhn S, Kallmann N, Gollhofer A. Combinatory effects of high-intensity-strength training and sensorimotor training on muscle strength. *Int J Sports Med* 2006; 27(10):401-406.
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 Gruber M, Gollhofer A. Impact of sensorimotor training on the rate of force development and neural activation. *Eur J Appl Physiol* 2004; 92(1-2):98-105.
 Gillespie LD, Gillespie WJ, Robertson MC, Lamb SE, Cumming RG, Rowe JB. Interventions for preventing falls in elderly people. *Cochrane Database of Systematic Reviews* 2003, Issue 4. Art. No.: CD000340. DOI: 10.1002/14651858.CD000340.
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 Hrysomalis C. Relationship between balance ability, training and sports injury risk. *Sports Med* 2007; 37(6):547-556.
 Mandelbaum BA, Shivers HJ, Watanabe DS et al. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. *Am J Sports Med* 2005; 33(7):1003-1010.
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 Myklebust G, Engelbreton L, Braekken IH, Skjølberg A, Olsen OE, Bahr R. Prevention of anterior cruciate ligament injuries in female team handball players: a prospective intervention study over three seasons. *Am J Sports Med* 2003; 31(2):71-78.
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 Sihvonen S, Sipilä S, Taskiran S, Era P. Fall incidence in frail older women after individualized visual feedback-based balance training. *Geriatrics* 2004; 59(6):411-416.
 Young EW, Young SS. Interventions for preventing lower limb soft-tissue injuries in runners. *Cochrane Database of Systematic Reviews* 2001, Issue 3. Art. No.: CD001256.

Several preventive approaches use a combination of SMT, strength training and technique optimizations. The effect of SMT alone is therefore difficult to quantify. [Olsen 2005 Owen 2006]

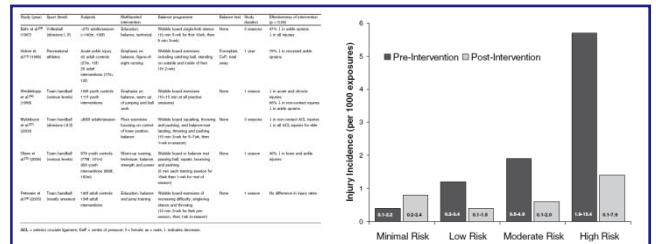


Fig. 2: Multifaceted intervention studies [Hrysomalis 2007] – left; Incidence of non contact ankle sprains by injury severity pre-post-SMT-intervention [McHugh 2007] - right

Stance stability in elderly persons is improved after SMT. In consequence, the frequency of falls is reduced. Gillespie et al. stated in a Cochrane Review after analyzing 21668 subjects (age >65), that "balance training" is one key element to achieve a reduction of fall events. [Gillespie 2003, Kanari 2003, Madureira 2007, Sihvonen 2004]

Concerning overuse soft tissue injury, no evidence is available for the efficiency of SMT to reduce injury risk. [Yeung & Yeung 2001]

Evidence in Athletic performance

Functional benefits apply for different populations (athletic, obese, elderly, subjects with chronic ankle instability). SMT results in improved postural control and dynamic balance. For optimal training loads see the poster "Loading Parameters". [Bellew 2005, Bernier 1998, Heitkamp 2001, Hue 2004, Kidgell 2007, Mafiuletti 2005, Nagy 2007, Paterno 2004.]

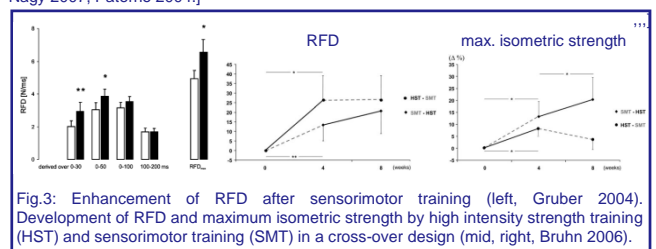


Fig.3: Enhancement of RFD after sensorimotor training (left, Gruber 2004). Development of RFD and maximum isometric strength by high intensity strength training (HST) and sensorimotor training (SMT) in a cross-over design (mid, right, Bruhn 2006).

SMT seems to improve the rate of force development (RFD) during maximal isometric force generation (Fig.3 left). Interference of simultaneous strength training and SMT have to be kept in mind (Fig.3 mid, right).

[Granacher 2006, Gruber 2004, 2007, Bruhn 2004, 2006]

Discussion and Conclusion

SMT can have substantial effects on risk reduction of traumatic knee and ankle injury, whereas positive effects on overuse injury risk reduction remains open.

Positive effects apply from athletic populations (injury risk, athletic performance) to elderly and special populations (obese) (enhanced postural control and dynamic stability, risk reduction of falls). Most results are available for the lower extremity. Other localizations should be addressed by research.

RFD, triggering several performance aspects, might be altered.